THE

TELEGRAPHIC JOURNAL AND ELECTRICAL REVIEW.

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AND

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The Telegraphic Journal.

VOL. III.] JANUARY 1, 1875. [No. XLVI.

THE COMPLIMENTS OF THE SEASON.

WE commence the new year with a new volume, and in wishing our readers all the compliments of the season we trust they will reciprocate that feeling by wishing us continued success in the publication of this Journal. That there is a large field for a technical periodical like this is not only evident from the wide and extensive range of telegraphic enterprise, but from the marvellous success of the Society of Telegraph Engineers. In three years that Society has sprung from a small coterie to a large and influential body of over 600 members, embracing all our leading electricians and telegraphists. Its past President is the first English Electrician of the day; its present President is the first Telegraph Engineer; its Council is composed of our leading men in the profession; its Members are spread over the whole face of the Globe, and its Proceedings form probably the most valuable records that have ever been published on telegraphic and kindred subjects. Though telegraphists are knitted together by wires which render them independent of the geographical resistance of seas, mountains, and rivers, and they are practically independent of space, nevertheless these bonds of communication are beyond their reach for purposes of instruction, discussion, and investigation. This can only be done by the time-honoured post. It is this function which this Journal is especially designed to fulfil. Its pages will contain contemporary history of all that is going on and being done in different countries. Elementary papers on various points connected with the technical branch of the profession will be continued; its columns will be open to discussion, and will form a medium for enquiry and investigation. The Society of Telegraph Engineers is the proper receptacle for original communications upon the results of investigation and research. It is hoped that the Members of that Society and the readers of this Journal will not fail to make use of those observant and reasoning powers with which they have been blessed to advance their profession and improve their own knowledge, by adding some little mite to the general stock of Telegraphic Science. The advance of Science is made by slow and short steps, such steps being the result of observation tested by experiment and confirmed by reason. If its progress were dependent upon one or two thoughtful observers its rate of progress would be slow indeed; but if the observers be multiplied and scattered, and if their observations be recorded and distributed, then its rate of progress will be considerably expedited. This, in fact, is the reason why Telegraphic Science has made such giant strides, and it is to continue this good work that our little Journal is framed into another volume and is launched into another year.

TELEGRAPHY IN 1874.

OF the progress of telegraphy in 1874 the principal portion appears to be that of the various Submarine Extensions, which have not only been numerous, but also important; South America having been brought into almost direct communication with Great Britain during the year.

In 1873 the section of the Brazilian Company's system from Lisbon to Madeira was partially laid, but, owing to the appearance of a fault, the work was stopped until the present year. On the completion of the section between Madeira and St. Vincent—a length of 1200 nautical miles—the broken cable off Madeira was recovered, and communication thus was established between Lisbon and St. Vincent. Subsequently the section between St. Vincent and Pernambuco—1845 nautical miles—was completed, and thus, by means of the Eastern Company's cable from Lisbon, was the Brazils brought into direct telegraphic communication with the United Kingdom. Consequently, upon the laying of the various cables belonging to the Western and Brazilian, the Central American, and others, communication was opened up between Demerara on the North and the River Plate on the South.

The Anglo-American Company succeeded in laying a fifth cable across the Atlantic, by means

of the cable left from last year, and a subsequent addition of 1100 miles of new cable. The *Great Eastern* was occupied in the work, and difficulties were encountered, as the weather was most severe. It is difficult to understand the operations of the Company, for they have gone to the expense of laying an entirely new cable, whilst they appear to abandon an existing cable (1865) which has been broken down.

An attempt has been made, by an opposition Company, to lay a separate and independent cable across the Atlantic. This has so far succeeded that the cable has been submerged across to within a short distance of Newfoundland, and there buoyed. It appears, however, to have a fault in it. Bad weather has for some weeks prevented any operation, so that the Direct United States Company have been unable to complete their communication during the present year.

Cables have been laid during the year between Jamaica and Porto Rico, and another short West Indian section, also between Constantinople and Odessa, between Zante and Otranto, and between Barcelona and Marseilles. The amount of mileage added to the submarine system has been very great, exceeding that of any previous year.

Accidents have been not infrequent, both at home and abroad, but from the rapidity of the repairs—showing the value of local repairing steamers—the interruptions have not extended over any great period.

Numbers of the Post-Office cables have been broken, but, with the exception of the English-Guernsey cable (broken for the second time), all have been restored. In the repairs to the Irish cable it was noticed that the hemp and gutta-percha had suffered very much from the appearance of several distinct kinds of "boring" worms, which had done much damage,—especially one kind, which attacked and penetrated the gutta-percha to so great an extent that a fault had occurred. These worms were noticed in the Wexford, as well as in the Holyhead and Dublin cable.

The Postal Telegraph Department have during the year introduced the Sounder as much as possible, and it may now be definitely considered as the instrument of the future: its various advantages have at last become apparent, and in time we shall observe its use as wide and extended as may be seen in the United States.

The Duplex continues to advance, and the Stearns's system is rapidly becoming extended. The advantages derived from the system of duplex working have daily become more and more apparent.

The important work of the transfer of the Postal Telegraph system from the old centre at Telegraph Street to the new buildings in St. Martin's Lane was most successfully accomplished during the first week of the year, reflecting the greatest possible credit upon those engaged.

DR. GLADSTONE'S LECTURES AT THE ROYAL INSTITUTION.

Dr. Gladstone, F.R.S., Fullerian Professor of Chemistry, commenced, on December 29th, a course of six lectures on the Voltaic Battery. Though they are adapted to a juvenile auditory, there can be no doubt that they are equally adapted to a large majority of our readers. We have much pleasure in announcing that the learned Professor has kindly consented to allow a verbatim report of these lectures to appear in these columns. The first lecture, on "The Cell and its Effects," will appear in our next. Junior telegraphists will do well to follow these lectures closely, and to repeat the experiments described in them. There is a great tendency to be contented with the description of an experiment, but students who really desire to learn should never be satisfied until they have made the experiment for themselves. It is the only way to acquire a knowledge of Electricity.

THE LATE REV. HENRY HIGHTON.

We have to record the very sudden decease, at his residence in The Cedars, Putney, of the Rev. Henry Highton, a gentleman long and well known in scientific, telegraphic, and scholastic circles. He was for many years one of the assistant masters of Rugby School, and afterwards for some time the principal of Cheltenham College. Mr. H. Highton was educated at Rugby under Dr. Arnold, of whom he was a favourite pupil, and between whom and himself there existed a strong personal attachment. Dr. Arnold, indeed, has left it on record, in a formal testimonial given shortly before his lamented death, that Mr. H. Highton was one of the best pupils who ever passed through his hands. As head of the school, and afterwards as one of its masters, Mr. H. Highton attained a lasting popularity, and in his shorter career as principal of Cheltenham he secured the attachment and respect of all the senior pupils. As a scientific man he is associated with various discoveries in connection with electrical telegraphy, for which he more than once received a medal from the Society of Arts. He took out his first patent as early as July, 1844, for a telegraph worked by static electricity and a chemical recorder. In 1846 he invented his well-known gold-leaf telegraph, which, however, was never practically used. A small strip of gold leaf inserted in a glass tube was made to form part of the line circuit, and it was placed between the poles of a large permanent magnet. Whenever the line currents passed through the gold leaf it was instantly moved to the right or left, according to the direction of the current. Its delicacy is so great that efforts have been recently made to introduce it upon our long-cable circuits. In 1848 he took out a patent, with his brother Edward, for a new form of needle telegraph, and various other modifications; and in 1850 the British Electric Telegraph Company was formed for the express purpose of working and bringing into more general use the inventions of Messrs. H. and E. Highton. He recently (1872-3) introduced a new form of battery, and has been engaged in perfecting a mode of working long submarine cables by means of his gold-leaf receiver, and a new electro-magnetic induction apparatus, by which the sensitiveness of telegraph instruments is considerably increased. He also, some years ago, invented and perfected a new kind of artificial stone, now largely used for paving and building purposes. Mr. H. Highton was formerly elected a Mitchell Fellow of Queen's College, Oxford, after highly distinguishing himself in both the classical and

mathematical class lists of that University. He was a candidate for the Head Mastership of Rugby at the period of Dr. Hayman's election.

ON DIRECT AND INDIRECT DETERMINATION OF THE POLES IN MAGNETS.

By TH. PETRUSCHEVSKY.

THE author gives the name absolute pole to the point upon which the parallel magnetic forces are directed. By relative pole he means the point where centre the resultants of magnetic forces not in parallel directions. If the word pole is used by itself, the absolute is implied in the absence of direct intimation to the contrary. As the most intense magnetic forces are concentrated in two small spaces near the ends of the magnet, they may be considered as parallel in relation to an external point proportionally near the magnet, and exposed to its action.

First Method for the Direct Determination of the Poles.—Let N O S (Fig. 1) represent the horizontal projection of a magnet, suspended from a point situate in the middle between N and S. Let the line M M′ be parallel to N S, and let both lie in one horizontal plane. Along the line M M, let small magnets, perpendicular to this line, and at the same time horizontal, be moved. These I call the needles. Let us first consider the action of the needle m upon the pole N, in the supposition that the distance N m is sufficiently great to allow of the pole N being regarded as absolute.

FIG. 1.

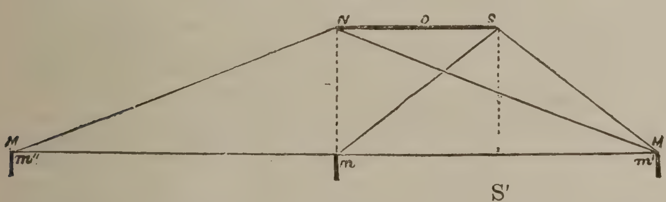
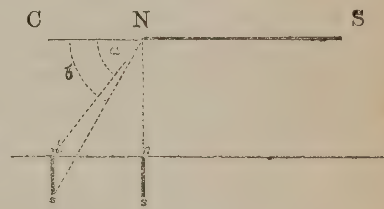


FIG. 2.



It may then be readily shown that the mutual action which the point N and the needle m exert upon each other, attains its maximum when m stands exactly opposite to the pole N. In any position whatever (Fig. 2) of the needle, $n' s'$, its action, T, upon the pole, N, may be expressed by the equation

$$T = p\left(\frac{\sin^3 a}{n\,N^2} - \frac{\sin^3 (a + \gamma)}{s\,N^2}\right)$$

p signifies a constant depending on the intensity of the magnet, N S, and of the needle; a, on the other hand, and $\beta = a + \gamma$ the angle C N n' and C N s'. If we now, without regarding the physical signification of the assumption, put $\gamma = 0$, the value of T evidently increases, so that

$$\sin^3 a\left(\frac{1}{n\,N^2} - \frac{1}{s\,N^2}\right) < \left(\frac{1}{n\,N^2} - \frac{1}{s\,N^2}\right)$$

that is on the supposition that $\gamma = 0$, the action of the needle, $n\ s$, upon the pole, N, is smaller than the last expression, and hence it must, *a fortiori*, be the full value of T. Let m (Fig. 1) be at the least distance from the pole, N. If beside its action there were no other, the position of the pole would be simply determined by the intersection of the produced needle, m, with the magnet, N S. But the action of the S pole upon the needle, m, modifies the above result, and we shall now, instead of this disturbing action, introduce one equal, but opposite. For this purpose a second needle, m', is introduced in the opposite direction to the former m, so that the one attracts the S pole whilst the other repels it. Both actions annul each other as soon as S m = S m', and the magnetic momenta of the two needles, m and m', are equal. There remains then the action of the needle m upon the pole N, which can be compensated by a third magnet, m'', which is placed in the opposite direction to the second, and for which N m'' = N m'. We will be satisfied with three needles, and assume that when moved they satisfy the above-mentioned conditions, *i.e.*, that on displacement of the needle, m, both the others move in such a manner that m S remains equal to m' S, and likewise m'' N = m' N. If these conditions are satisfied, we may limit our consideration to the action of the needle m upon the pole N, and the problem is thus solved. The above-mentioned conditions involve that the movements of the needles m and m'' are always alike, but those of m and m' are opposite in direction. The speed of motion for all three magnets must be equal.

The movements required by these conditions can be secured by a screw which has at its two ends equal but opposite threads.

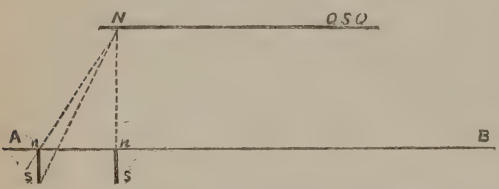
The position of the needles m, m', and m'', is arranged at first approximately, and so that the middle of the distance, $m\ m'$, arbitrarily selected lies opposite to the point S, which is also approximately determined according to the considerations of Coulomb. We assume, firstly, the distance of the point S′ from the end of the magnet at 25 to 35 m.m., according to the size of the magnet, and commence thus the measurement. We determine first the position of the pole N, moving the system of needles till the greatest action is attained between m and N. The position of the pole S is then determined. If this latter determination deviates much from the assumption made at the commencement, the determination of N must be repeated, the position last found for S being retained.

After some observations made by this method, I gave it up, and replaced it by a more simple process.

Second Method for the Direct Determination of the Poles.—Let the position of one pole, S, be known; let the magnet be suspended by this pole, and kept in equilibrium horizontally by a counterpoise (Fig. 3); let a small magnet, $n\ s$, move in this horizontal plane, in the direction A B parallel to N S, whereby it remains constantly perpendicular to A B. If the point of suspension of the magnet coincides exactly with the pole S, the

determination of the other pole, whose position we assume as unsymmetrical, is very simple. For this purpose, as in the first method, we have to find that position of the needle, $n\ s$, with respect to A B, in which its action upon the magnet, N S, attains its maximum value. The point of intersection of

FIG. 3.



the produced needle with the main magnet is then the pole sought for. In general, however, the pole S does not coincide exactly with the point of suspension Q, as it has been only approximately determined by the experiments of Coulomb; hence the needle, $n\ s$, has a greater or smaller action also upon the shorter arm of the magnet. The question is now under what conditions the displacement of the needle, $n\ s$, is accompanied by such changes in the reciprocal action between it and the magnet under examination, as are exclusively produced by the action of the needle, $n\ s$, upon the pole, N.

Let $2\ L$ signify the distance between the poles N and S.

$\pm \delta\ L$ that between the pole S and the point of approximation.

D that between the lines N S and A B.

Z that of the needle $s'\ n'$ from the point of its maximum action (*i.e.*, $Z = n\ n'$).

l the distance between the two poles of the needle, $n\ s$.

The action of the needle, $n\ s$, upon the pole, N, is then—

$$k = \left(\frac{\cos n'\ N\ n}{n'\ N^2} - \frac{\cos s'\ N\ s}{s'\ N^2}\right)(2\ L \pm \delta\ L) =$$

$$\left(\frac{D}{n'\ N^3} - \frac{D + l}{s'\ N^3}\right) 2\ L \pm \delta\ L).$$

But as—

$n'\ N^3 = (D^2 + z^2)^{\frac{3}{2}}$ and $s'\ N^3 = [(D + l)^2 + z^2]^{\frac{3}{2}}$,

therefore—

$$k = (2\ L \pm \delta\ L)\left(\frac{D}{(D^2 + z)^2]^{\frac{3}{2}}} - \frac{D + l}{[(D + l)^2 + (2\ L + z)^2]^{\frac{3}{2}}}\right).$$

In like manner we find the momentum of torsion in the action of the needle, $n'\ s'$, upon the pole S. If we put it = F, then

$$F = \delta\ L\left(\frac{D}{[D^2 + (2\ L + z,)^2]^{\frac{3}{2}}} - \frac{D + l}{[(D + l)^2 + (2\ L + z)^2]^{\frac{3}{2}}}\right).$$

In order that in a displacement of $n'\ s'$ the alteration of k thus produced may be greater than that of F, the condition $\frac{d\ k}{d\ F} > 1$ must be kept in view, since then the changes in the position of the magnet under examination must be chiefly ascribed to the action of $n\ s$ upon N.

But now—

$$\frac{d\ k}{d\ F} = \frac{2\ L \pm \delta\ L}{\delta\ L} \cdot \frac{z}{2\ L \pm z} \cdot \frac{\dfrac{D + l}{[(D + l)^2 + z^2]^{\frac{5}{2}}} - \dfrac{D}{(D^2 + z^2)^{\frac{5}{2}}}}{\dfrac{D + l}{[(D + l)^2 + (2\ L + z)^2]^{\frac{5}{2}}} - \dfrac{D}{[D^2 + (2\ L + z)^2]^{\frac{5}{2}}}};$$

or, finally—

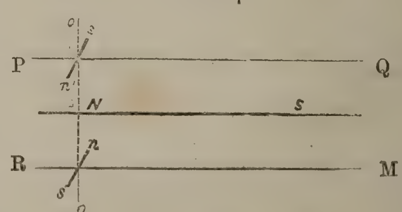
$$\frac{2\ L \pm \delta\ L}{\delta\ L} > \frac{2\ L \pm z}{z} \cdot \frac{\dfrac{D + l}{[(2\ L + z)^2 + (D + l)^2]^{\frac{5}{2}}} - \dfrac{D}{[(2\ L + z)^2 + D^2]^{\frac{5}{2}}}}{\dfrac{D + l}{[z^2 + (D + l)^2]^{\frac{5}{2}}} - \dfrac{D}{[z^2 + D^2]^{\frac{5}{2}}}}.$$

If in the last expression we insert, instead of the symbols, the numerical values, as experimentally determined, we may convince ourselves as to whether the condition has been fulfilled or not. In the latter case the values of D and l have to be altered till the numbers suit the formula. To be finally satisfied as to the accuracy of the determination of the position of the pole, we may proceed as follows:—After the one pole, *e.g.* N, has been ascertained as above directed, the magnet is reversed, and suspended by its N pole, whilst the position of the S pole is determined. The magnet is then again suspended by the S pole, but more accurately than before, and the position of the N pole is once more determined. Experiment shows that the result of the second determination differs from that of the first within the limits of errors of observations. This method, as well as the previous one, renders it practicable to determine the position of the poles even when they are not symmetrically distributed.

Before describing the apparatus used for determining the poles, I will point out certain sources of error which may possibly occur.

(*a*). The needle must, when displaced, always be set vertically, both to the direction of displacement, R M, and to the axis of the magnet, N S. From

FIG. 4.

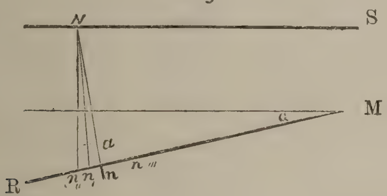


any deviation of the needle from the perpendicular there results an error in the determination of the pole, which, however, can be eliminated by means of two observations—in one of these the needle lies the right, and in the other to the left of the magnet. In Fig. 4, N S is the suspended magnet, P Q and R M two lines equidistant from and parallel with NS. Let $n\ s$ be the position of the needle in the first observation, $n'\ s'$ in the second; further, let the line o N o' pass through the N pole, and be perpendicular to the three parallel lines. In the first position the N pole falls on the one side of the

line $o\ o'$, and in the second position on the other. If we assume, as is warranted by the construction of the apparatus, that the two directions $n\ s$ and $n'\ s'$ are parallel, it follows that if the first determination of the pole gives a positive error, that in the second determination must be negative. According to the one measurement the distance of the pole from the extremity of the magnet is $R + p$, according to the other $R - p$. Half the sum of the two $= R$ is therefore free from the error in question.

(b). Let the needle be fixed perpendicular to its direction of displacement, R M (Fig. 5); let

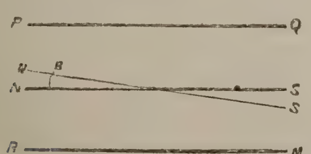
FIG. 5.



this not be parallel to N S, but situate in the same plane with it; let m be the position of the needle in the case when its production touches the pole N; let n N not be perpendicular to N S. A removal of the needle towards n' increases both its distance from the pole N and the angle S N, which in the position n'' becomes a right angle. A movement towards n'', on the other hand, increases the distance, and decreases the angle. An increase of the acute angle, S N n, increases the momentum of the action of both magnets, whilst a decrease of the same angle has the opposite effect. An increase of the distance diminishes the force with which the poles act upon each other, whilst a decrease augments it. Hence it is evident that the maximum of action occurs in some position between n and n''. The angle n N n'', which we will call α, is equal to the deviation of the direction R M from parallelism with N S. Calculation shows that the maximum occurs for a point n', whose position in R M is thereby determined that the angle n N $n' = \frac{1}{3}\,\alpha$. A needle at this point, if sufficiently produced, meets the magnet in N , instead of in N, which is the true pole. The error thus committed can be detected by calculation as soon as α is known. I have, however, preferred to diminish α as far as possible by means of a careful construction, described below.

(c.) Suppose the magnetic and geometric axes are in the same plane, but not parallel. If R M is placed parallel with the geometric axis, N S, the magnetic axis, N′ S′, forms with R M (Fig. 6)

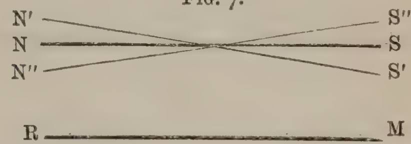
FIG. 6.



an angle β, whose influence upon the result of the measurement has been explained above. In order to eliminate the error arising from the want of coincidence of the magnetic and geometric axis, two observations must be made, one on each side of the magnet, whereby, however, both lines, R M and P Q, must be parallel with the geometric axis, N S. If in the one case the distance of the pole from the extremity of the magnet $= l$, and in the other case $= l'$, the true distance is $\lambda = \frac{l + l'}{2}$. This result follows from the approximately accurate supposition that $l = \lambda + q$, and $l' = \lambda - q$, q standing for the error arising from the deviation of the magnetic from the geometric axis.

(d). Suppose the magnetic axis does not lie in the same plane with the direction of displacement of the needle. In this case the horizontal projection of the axis can be taken into calculation, instead of the axis itself. The position of the pole as found for the horizontal projection departs very little from the true position, as the angle formed by the mag-

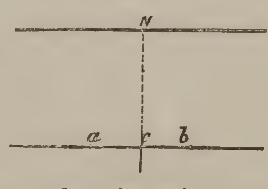
FIG. 7.



netic and the geometric axis is very small. If, $e.g.$, the distance of the poles is 200 m.m., and the angle of the axis 1°, then in the most unfavourable position of the magnetic axis, $i.e.$, when it falls in a plane perpendicular to the geometric axis, the position of the pole, as determined in the horizontal projection, only varies from the true position by 0·1 m.m.

(e). If the needle is pointed accurately towards the pole, a considerable displacement of it corresponds to a relatively slight change in the action of the needle upon the magnetic pole, and the position of maximum action cannot be determined with the accuracy desirable. To overcome this obstacle I make two observations, turning the needle alternately right and left from the supposed point of maximum action. Suppose at the beginning of the experiment that the needle is at the point b (Fig. 8), and is now approximated to

FIG. 8.



the position c, where its action upon the N pole is greatest; without stopping at this point, I move the needle onwards to a certain point, a, where it repels the N pole with the same force as in b. If $a\ b$ is trifling in comparison with the distance between both magnets, the middle point of the line, $a\ b$, may be taken as the position where the action of the needle is greatest.

The accuracy of my method depends, among other things, upon the circumstance that the magnetic axis is parallel with the direction of displacement of the needle. Hence it follows that the maximum action between the two magnets cannot be determined by the greatest deviation of the magnet under examination from its original position. Suppose the magnet is in its place before the needle is brought into position; the magnetic

axis of the former will then take the direction of the magnetic meridian. As soon, however, as the needle is fixed up, the former varies from its position, and the pole withdraws from the needle. In order to bring back the magnet to its original position, another magnet, which we may call the compensator, is approached on the side opposite to the needle. Suppose that the needle was at the point b: if it is moved from its place, the suspended magnet deviates again from the direction of the meridian. But if the needle is moved further, a new position a can be found for it, in which the magnet returns to the meridian. If the compensator remains hereby unmoved, the action of the needle upon the pole of the magnet is the same at a and at b.

(To be continued.)

EARTH-BORING FOR TELEGRAPH POLES.

By JOHN GAVEY.

THE usual method of digging a post-hole with the pick and spade requires but a brief description. A rectangular opening, averaging 4 feet by 2 feet, is made in the ground, and the earth moved uniformly throughout to a depth of 2 feet 6 inches, whence, by a step-like arrangement, the length of the hole is gradually shortened, until at the bottom it does not exceed 1 foot.

The depth at which it is customary to plant telegraph poles may roughly be considered to vary from 4 feet 6 inches for a pole 24 feet long, to 5 feet 6 inches for one 28 or 30 feet; 6 feet serving up to, say, 40 feet, and 7 feet for any height.

It may be taken, as the result of experience, that the average number of holes which a workman will dig in ten hours is represented in the following table:—

Soil.	No. of Holes per Day. 4 ft. 6 ins. deep.	5 ft. 6 ins. deep.
Clay	6	5
Digging soil ...	5	4
Hard gravel ...	4	3 to 3½

The digging of a pole-hole 4 feet 6 inches deep may be said to involve the removal of 30 cubic feet of soil, which will represent a weight varying from 2850 lbs. to 3600 lbs., according to the nature of the soil; whilst one 5 feet 6 inches deep will contain 44 cubic feet, with a weight of 4180 lbs. to 5280 lbs. This allows for the step-like manner in which such a hole is generally dug.

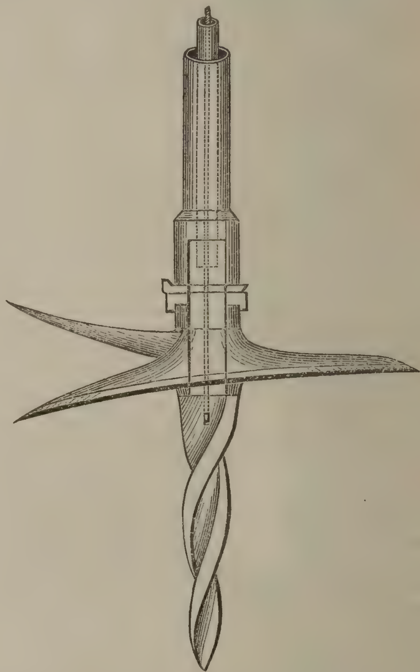
To reduce the great amount of unnecessary labour here involved, the most obvious step is first of all to effect a reduction in the size of the hole. The first instrument invented for carrying out the object was the "Spanish spoon." It consists of a circular metal disc, the chord of the arc forming a cutting edge. The periphery of the disc was provided with a ledge about 2 inches high, to retain whatever might accumulate on its surface, and the whole was fixed at right angles to a long handle.

Various modifications in the form of the spoon have been introduced with more or less success: but the principle of all forms of this apparatus is the same, namely, loosening the soil with a suitable bar, and collecting and raising to the surface the *débris* thus broken away.

* Abstract of a Paper read before the Society of Telegraph Engineers.

The most marked improvement in the method of opening holes for telegraph poles appears to have been the introduction of earth-borers, amongst which may be mentioned those invented by Spiller by Marshall, and by Bohlken.

Spiller's is but a modification, on a large scale, of the ordinary ship's auger; Marshall's and Bohlken's are both constructed on the same principle, but are essentially different from Spiller's. A general idea of their construction can be obtained from the accompanying diagram of Marshall's apparatus.



Spiller's borer the author found to be very effective in sand, clay, and ordinary soil, but ill adapted for gravelly or stony ground. Marshall's borer was very effective in ordinary soil, clay, and gravel.

These borers have obviously one defect: they cannot be worked close to a wall or a hedge, positions where—in road telegraphy especially—it is frequently necessary to erect poles. This difficulty has been overcome by fitting one of the borers with an ordinary ratchet handle, lightening such of the parts as admit of it, and replacing the long tapering point by a shorter one. This modified instrument will bore in clay and ordinary soil, but in gravel it only acts as a spoon, the soil having to be broken up with a bar.

The advantages of these apparatus may be summarised as follows:—

1. Speed: a number of pole-holes can be opened out to a given depth, with the same force of men, in less time than by ordinary methods.
2. Diminution of labour in filling in.
3. Greater solidity of the pole thus erected.
4. Less disturbance and mixing up of the soil,—a point of some consequence in erecting lines of telegraph through private property.
5. The advantage of being able to work in wet soils without baleing or pumping.

No. of Hole.	Time Boring. Mins.	Depth. Sand and Loose Soil. Feet.	Clay and Marl. Feet.	Gravel. Feet.	Remarks.
3	28	—	3·6	2·0	
4	47	3·0	—	2·6	
8	80	—	2·6	3·0	Nos. 7 and 8 bored for A pole, 35 mins. additional taken up for widening both holes.
9	40	0·9	2·9	2·0	
10	58	—	3·6	2·0	Plate broken.
14	63	—	2·9	2·9	Nos. 10, 14, 16, and 18 poles, three men with sheers were told off. The sheers erected for drawing borer, and, when hole complete, used for raising pole. Work done entirely by them.
16	63	—	2·9	2·9	
18	87	—	2·0	3·6	
	466	3·9	19·9	20·6	

6. Saving of expense in sharpening and laying pickaxes.

Amongst the disadvantages may be mentioned:—

1. Strain involved in raising the borers out of heavy soils, with their load of *debris*.
2. The difficulty and—with inexperienced men—danger in rearing the pole into the hole, when the former is very heavy.
3. Liability of the screw-borers to fracture, and additional first cost.

After entering fully into each of these, the author concludes a valuable practical paper by appending several interesting tables, showing results which had been obtained with the borers. From these we extract the one (see above) for Marshall's 12" borer, which has given on the whole the most general satisfaction.

Mr. Gavey added that he had received from Mr. Langdon a letter, in which the writer said that he considered that there was a possibility that, in some soils, the varying strain occasioned by the force of the wind might gradually work the poles out of the ground. Mr. Langdon suggested and described in his letter the addition of a semi-circular iron flange near the bottom of the poles, in order to secure their stability in the ground. He (Mr. Gavey) thought that there was very little danger of the poles being forced up in the manner described. Where the ground was sufficiently solid, the stability of a pole erected in bored holes would be sufficiently great to resist all ordinary pressures. He had that day inspected a length of line which was described in the paper as having been put up in bored holes, and he found that, although the line carried heavy No. 4 wires, the effect of which in ordinary cases was well known, not a single pole had moved, and not a single shilling had been spent on the line, although the gales of three winters had blown over it. That was a very good example of the stability of poles erected in the manner described.

Mr. von Fischer Truenfeld said that, having had some experience with earth-borers, he wished to state a few disadvantages which were not mentioned in the paper. The paper spoke of the greater solidity of poles erected in bored holes; but that supposed that the earth was properly rammed in. He had, however, found that there was a certain difficulty in ramming in the earth. There was always a very small space between the pole and the side of the hole, and in many cases the pole failed to be exactly in the centre, and hence there would be certain places where it would be very difficult to use the rammer. Some soils, too, as, for instance, wet clay, offered very great difficulties to the entrance of the rammer into the narrow space between the pole and the ground. Open spaces would sometimes be left against the side of the pole, and these would become filled up with water, which would tend to destroy the wood. Those defects were not likely to occur if the hole was dug in the ordinary way. The system of boring involved the use of more tools than were required in the ordinary process of digging, and he always thought that it was a disadvantage to use very many tools, especially in countries where long lines had to be erected, as in the interior of Australia or Russia. In the year 1863 he took out earth borers from England for the purpose of erecting a telegraph in the Republic of Paraguay, and he found that the men, who were very good workmen, would rather do the work without the borers than with them, and, in fact, he had to give up the use of the borers, though against his will.

The President (Sir William Thomson) asked what tools the men objected to.

Mr. von Truenfeld said that he used exactly the same sort of borers as those which were then exhibited, though they were not so long.

The President asked whether the men who preferred the pickaxe and shovel were men who were inexperienced with the borer.

Mr. von Truenfeld said that the work was done by soldiers, as the lines were purely military ones. The men were very well trained soldiers, and workmen of the first class. One of the reasons why they objected to the borers was that they had to take too many tools with them. The paper stated that it would be necessary always to carry a pickaxe and shovel, as there were certain places in which the borer could not be used. Consequently the number of tools would be large, and the men found the quantity very disagreeable if they had to travel many miles a day, and shift their tools from place to place. It was important to reduce all the appliances to the very smallest quantity. The men did the work just as quickly with the shovel. He never used shear-legs for erecting the wooden poles, as such an appliance would be an addition to the tools to be carried about. The men lifted the poles by hand, and as they were lowering them into the ground it often happened that a pole would knock the sides of the hole, and a piece of earth would tumble down before the pole reached the bottom, and would prevent the pole from going to its proper depth. He had seen this occurrence repeatedly. He believed that earth-borers of smaller dimensions—for instance, about five inches in diameter—might be advantageously used in erecting provisional military field telegraphs.

Mr. Graves said that some years ago he was under the impression that they might supersede the use of the spade and pickaxe by the introduction of mechanical means which would lessen the labour and lessen the quantity of earth disturbed in erecting poles; and so far as experimental trials went, he should have been justified in speaking quite as highly of the borer as Mr. Gavey had done, and more highly of the Spanish spoon. On one occasion he assembled the chief officers in his own division for a trial near Coventry, on soils of various sorts, and they compared the use of the

borer and the spoon with the ordinary method of making holes with the spade and pickaxe. It was found that, except in the case of rock and hard gravel, the borer showed a decided advantage. Its performances were very clean; the work was done quickly; and it was found possible, with care and under supervision, to lower the poles into the holes without difficulty. But, on the other hand, even in that instance, certain drawbacks developed themselves which afterwards proved a serious obstacle in practice. One was the very great labour attendant on the use of the borer. After a depth of two feet had been reached, every lift became a series of hard continuous work to the men, and there was no relaxation, for the work became a perpetual mill-horse round, followed by a heavy lift, and the deeper they went the harder the work became. It appeared to him that, even on that ground alone, the borer was likely to become an unpopular instrument with the men. His experience had been that when they tried a test experiment under the supervision of superior officers who were interested in bringing out the best theoretical result, they generally got something which the practical use of the same instrument by workmen under ordinary conditions, did not confirm. He had distributed the borer and the spoon throughout the various gangs working in parts of the country with which he was connected, and had asked for reports as to their success. During the first month or two the officers reported very favourably of both the new instruments, but, on the whole, more in favour of the spoon than of the borer; but he had found that in the course of six months, except in a few special instances, the whole of the novelties had quietly dropped out of use. They had been reported upon, and then ceased to be employed. In spite of the manifest advantages of the borer, a large space of ground had to be traversed while it was being used, and thus crops might be injured to a large extent, and there was a difficulty in working the instrument except in open spaces. A large portion of the work for the Post Office had to be done close to the bottoms of hedges, or the banks of canals, and in either instance it would be impossible to work the instrument. The Spanish spoon, so far from being abandoned, was the only mechanical instrument which, in his division of the postal service, could be said to have any vitality. His staff had made many modifications in the shape of the spoon, but the general result was that it could be worked in a limited space where they could not obtain room for the use of even the ordinary spade and pickaxe. In loam or clay, where the borer could cut easily, the difficulty lay in lifting the earth when cut; and in those cases in which there was hard gravel or soft rock, the borer, for all practical purposes, became a spoon, as the soil had to be smashed first, and then lifted. Such a process of lifting, however, could be more easily and more rapidly effected by the use of the spoon. In erecting a road line of forty miles from Birmingham to Derby, he had arranged that the work should be done, as far as possible, with spoons; and amongst a gang of thirty men there were only three spades, and the whole of the line was erected by the use of the spoon, under two foremen of competent experience, and the result was so far satisfactory that the cost for labour was not on the average greater than would have been occasioned by the use of pick and spade; and there was an absolute gain in the fact that the earth was not removed to so great an extent. But beyond that he was bound to say that the economical gain was absolutely nil. The advantage gained in labour by a smaller quantity of earth having to be removed was lost by the increased labour of fixing the poles; and when the poles were heavy, a large number of men had to be collected, at short intervals, from their other employments, in order to set the poles into the holes; and in many cases it happened that the sides of the hole were broken, and the holes were half filled up, so that they had to be spooned out again. He might add that, although this result, which was so far satisfactory that it did not cost more than the erection of poles in the ordinary manner, was obtained by a large gang working under competent supervision, he did not find that it was practicable to enforce the use of any substitute for the spade in the the case of a few men working by themselves. The workmen instinctively clung to the spade, and his experience coincided with that gained by Mr. von Truenfeld in Paraguay. He believed that neither the spoon nor the borer was used in his division to any appreciable extent.

Mr. Bell said that he thought that Mr. Gavey, in referring to the old method, had given rather a bad case as to the quantity of earth which it was necessary to remove. He had given a measurement of two feet, but he (Mr. Bell) thought that one foot six inches was ample space for a man to work in. There was one point upon which it was necessary to have a little information. In the drawing of the A pole the curves were shown, and it was apparently assumed that the friction of the earth upon the pole was such that, when the pole was canted over under strain, the earth would be caused to move in the direction which was shown. He wished to know whether that point had been really subjected to any test, for, unless the pole had a very considerable taper at the bottom, he did not think that the earth would have such a hold upon it as to avoid its being canted over. It was, however, clear that, in the case of such a small base, and the height of the pole being so much greater in proportion, when a atrain came upon the pole one leg would go down slightly into the soft earth, and the other leg would be lifted, if there was no sill-piece or tie such as was shown in another diagram. He thought that Mr. Langdon, in his letter, had pointed out rather a weak point, and that it was necessary to adopt something of the kind which he had recommended, in order to give the poles a good hold of the soil.

The President—It seems to me that the resistance to tilting over in the case represented in Fig. 7 would depend solely upon the force required to pull either pole directly up.

Mr. Bell concurred, and said that it seemed that the resistance depended upon the friction of the earth against the pole. Unless there was a very considerable friction, which they could scarcely imagine would be obtained by mere ramming, an excessive strain would certainly draw one foot up and depress the other, according to the softness of the soil.

Mr. Burton, Director of Telegraphs in the Argentine Republic, said that what Mr. Truenfeld had said with respect to the falling down of earth was a matter of fact, and it would be a disadvantage either to have the pole higher than it ought to be in the ground, or to have to take the pole out of the ground in order to remove the earth which had fallen under it. It should be considered also that in other countries they were unable, as a rule, to obtain poles in the same form as we had them in England. For example, he had about 30,000 wooden poles on his line, and out of any hundred poles it would be impossible to find five which were straight, and in such a case the borers would be practically useless. If the holes were bored of sufficiently large dimensions to receive such poles, the ramming down would be a matter of serious difficulty, and would leave cavities which would be filled up by water; or, if the poles were not injured in this way, they would get loose, and men would have to be continually employed in putting them straight, especially on curved portions of the line.

Mr. W. H. Preece asked Mr. Burton what was the nature of the wood used in the Argentine Republic.

Mr. Burton replied that, as a rule, the wood was of

a very hard kind. There were two kinds which were generally used. One was Algaroba, and the other was Quebracho Colorado. It was somewhat difficult for a man who was not well accustomed to the colour of the wood to distinguish between Quebracho Colorado and Quebracho Blanco. The Quebracho Blanco was a wood which would not last above one-third of the time the Colorado would last, and consequently any cavities which might be left in the ground by imperfect ramming would materially affect the durability of the Quebraco Blanco.

Mr. Preece asked what the life of a pole was considered to be in the Argentine Republic.

Mr. Burton said that, from his experience, he should think that, if the best kind of wood was used, the poles could be left for fifty years in either a perpendicular or a horizontal position, without suffering any deterioration whatever. The wood was so heavy that it could not be got in the capital of the Republic except to a very slight extent, as the cost of transport was very great, and the roads were as yet in a most primitive condition, and there were no railways to the interior. It was cheaper to use wood obtained from either Europe or the United States. This timber was abundant in the northern provinces, forming forests of a hundred miles or more in extent, with but small intervals between them. The wood itself was very cheap, and at the commencement of the construction of the telegraph the poles could be bought for about ten shillings each, but the proprietors, in consequence of the demand, had raised the price to about thirty shillings a pole. He had no idea of the age of the trees from which the poles were cut. The trees grew along the river coast, but it was perfectly useless to attempt to bring them down to Buenos Ayres, as the carriage by water was very expensive, and the wood sank if it was formed into a raft.

The President asked whether they were to understand that no form of borer had been found suitable for telegraph work in the Argentine Republic.

Mr. Burton replied that a borer had been used by one contractor, but he found it useless in consequence of the irregular form of the tree, and, in addition, there was the objection of which Mr. Truenfeld had spoken, namely, the dislike of the men to carrying many tools. He (Mr. Burton) had had to dispense with many of the tools for maintenance which would be used in England and other countries where transport was easy. The men had always to go on horseback, and travel very great distances every day.

Major Malcolm said that Mr. Truenfeld had suggested that the borers would be very useful for military telegraphs. He should like to ask whether that gentleman had himself tried the smaller borer for such work. One objection to the small borers would be that the V-shaped opening, being small, would get jammed up with stones, and the borer would have to be perpetually pulled up from the ground in order to be cleared. Another objection was that, in his experience, he had found that, owing to some manufacturing defect, the borers broke in the pipe.

Mr. von Truenfeld stated that the borers which he used in Paraguay were about five inches in diameter, and they were much shorter and stronger than those exhibited at the meeting. Their length was about four feet. He used them for boring holes about three feet deep, and the poles were made of a tree of a very good round shape. The soil in which the poles were fixed consisted chiefly of clay and sand.

Mr. Culley said that three years ago he gave very great attention to the question of boring, for he thought, and indeed many others thought, that very great advantage would arise from the use of boring tools. He caused tools to be sent through the country, and experiments were made in many places. After the experiments had been made for some time, he called for reports, and many of the reports which he had received treated the question in the most practical and precise way. The report from Nottingham spoke of Marshall's borer, and the writer said, "In clay, two men bored one hole, five feet six inches deep, in thirteen minutes, with fourteen lifts." This meant that the borer was lifted from the ground fourteen times. The lifting was the most difficult part of the work. The borer was screwed four inches into the ground, and the men had to put their arms under the cross bar, and lift the tool bodily out. The report from Doncaster said, "Where the earth is loose or soft, good progress may be made with the borer, but where the ground is harder the borer becomes almost useless, and the use of the borer and spoons only becomes more slow than the ordinary process of digging. With either the spoon or the borer all large stones have to be broken up before they can be drawn out, while in the ordinary way they are easily got out by digging." He had received reports from Ireland, from which the general conclusion appeared to be that, where the soil was of such a nature that spoons could be used, such tools were very much to be preferred to the pick and shovel; but the cases were so many in which the pick and shovel must necessarily be used, that it seemed doubtful whether it was advisable to carry double sets of tools with all the gangs, for the pick and shovel would of course answer for every purpose, while the Spanish spoon alone would not. In Ireland the borer had not been tried. He had recently made enquiries throughout the country as to whether the use of either the borer or the spoon had survived, and he found that they were not used anywhere. There was a report from Newark from which it appeared that Marshall's borer and the spoon were both good tools in certain grounds, but they both required a "knack" or experience in working, and that being the case, their use could be profitably brought about only where the same workmen are employed continuously. There was no doubt that in introducing any new tool, there was an immense amount of *vis inertiæ* to contend with, and the borer and the spoon, very probably, had had to contend with that disadvantage. This obstacle had impeded the introduction of pulley-blocks for straining up the wires, but it had at length been overcome, and now there was not a single wireman who would not require a set of pulley-blocks before he set to work. When the deputation from the American Western Union Company was over in this country, he enquired of the general superintendent as to the use of the borer, and the reply was that he, at any rate, never used the pick and shovel at all for fixing poles. No doubt the difficulty arising from the earth being pushed down into the hole by the butt of the pole could be met by special apparatus, in the form of a tub or tube, made to fit in the upper part of the hole, but all such things would have to be carried with the men, and the same apparatus would not fit every hole, and hence there might be an inconvenient multiplicity of appliances. It did not appear to him that the punning up of the pole formed any insurmountable objection. Mr. von Truenfeld had said that there was no room in the hole for punning, but by using a punner with an end somewhat curved, so as to fit the circumference of the pole, that difficulty was met, and they could pun very well in a width of two inches or two inches and a half. But the great difficulty, after all, in using boring tools was that men had to be trained in their use, while labourers accustomed to the use of the pick and spade could be met with in any part of the country, and set to work directly. He hoped, however, that they would not give up the trial of these tools; but he must confess that he had very much less hope of their being ultimately successful than he had three years ago.

Mr. Golstone said that some time ago he was so satisfied with some experiments which had been made

with the borers that he gave them into the hands of a foreman to construct a line of poles by the side of a railway. The work proceeded very well while the men were working on level ground, but the borers were found to be utterly useless when they came to the side of any bank in which the ground had been disturbed, whether the bank sloped down from the line or formed the side of a cutting. It would be necessary, in devising borers, to make something of universal application, if such tools were to be successful. Railways were particularly interested in this question. In many cases banks were made of new tipping, and the soil was placed very lightly, so that it was difficult to fix poles in such places. An effective borer would save a great deal of trouble in such cases.

Mr. Gavey, in reply, said that one of the objections which had been raised to the use of borers was the number of tools which the men had to carry. He quite admitted that, if the spade and pickaxes, and a variety of other tools as well as borers, would have to be carried, it might be necessary to abandon the use of the borers. But in a country like England the officer in charge of the line generally knew the character of the soil on which the line was to be erected, and he could act accordingly. If the use of the borer was inadmissible on any particular soil the holes could be made with other tools. A great point had been made as to the small space which existed between the pole and the ground, and the want of room for ramming. He had always considered that the smallness of the space which existed between the pole and the ground was one of the great advantages of a bored hole. Something had been said as to the use of borers abroad, but in dealing with the subject he had referred more to their use at home, where, as he had said, the officer in charge could use his own discretion as to the tools which would suit the soil. In foreign countries it might, of course, be advisable for the officers to rely only upon such tools as they knew could be used under all circumstances. With reference to Mr. Graves's remarks, he (Mr. Gavey) was not aware whether Mr. Graves had used the small modified instrument which was referred to in the paper as Marshall's spoon. That was an instrument which was well adapted to overcome many of the objections which had been raised to the borer itself. It was quite true that, with a heavy borer, the men were unable to open an hole near a wall or an embankment, or in a confined space, but, with the small ratchet borer which he had referred to in the paper, that difficulty was thoroughly overcome. That instrument would bore very fairly in clay and in light soils. In heavier soils it might be used only as a spoon, as the soil had to be broken up; but it had certainly been his opinion—and he ventured to say that it was his opinion still—that with that instrument they could collect the soil more readily than they could with the Spanish spoon. With regard to diagram No. 7, he understood from Mr. Bell that it was that gentleman's opinion that the only hold which the soil had on the pole was the friction between the surface of the pole and the soil itself. That would be so if the pole was raised vertically out of the ground by means of shears, but he did not think that that was the kind of action which would occur. Of course if the poles were not rigid they would bend, and under such circumstances they would be drawn out, and would simply be held by the friction existing between the poles and the soil; but he scarcely thought it was a correct view of the case that such a condition would exist. With reference to the general use of borers he thought that there was, no doubt, difficulty, as had been said by several speakers, and one of the greatest objections to the use of the borer was certainly the difficulty in withdrawing it from the soil. The second great objection was the difficulty in rearing the pole into the hole. But those difficulties were very fairly met by the means which he had described, and he did not think that the additional weight, in the shape of tools that had to be carried, by adding a pair of light shears to each gang was worth much consideration. He believed that one of the causes which had led men to object to the use of borers was the physical strain which was involved in raising the instrument out of the ground; but if that strain was removed by some simple means, such as shears and a pair of blocks, the objections would very soon vanish. He had found no difficulty in getting the men to do the work with borers when they were provided with the means of avoiding the great physical strain to which they would be otherwise exposed. One erection of the shears served for the whole operation with regard to each pole. He had found no difficulty in lowering the pole without knocking the earth from the sides of the hole, and so partly filling it up. But certainly any such contingency could be provided for by making the hole six or eight inches deeper than the height of the pole required it to be.

The President, in closing the discussion, said—I wish to make just one remark upon diagram No. 7. The disadvantage of the method in No. 6, as I understand it, is the large quantity of loosened soil that it involves. The advantage it presents is the presence of the cross-bar, which cannot move upwards without dragging a large quantity of soil with it. But on referring to diagram No. 7 I think that, notwithstanding the comparatively small quantity of soil loosened in the process of executing it, we have an arrangement which could not possibly be advantageous, even with the addition of ratchets projecting out as in the additional (not numbered) diagram before us. It appears to me that in diagram No. 7 we have a mechanical arrangement devised, as it were, for the purpose of plucking out one or other of the poles. As the arrangement is described in the paper, it is stated that if the fulcrum were B, the lines of motion would be those shown by the full curves; or if the fulcrum were D, the lines of motion would be those indicated by the dotted curves. Probably in the actual case the virtual fulcrum would be somewhere between the two—B and D. The line of motion then of the middle of the immersed part of the pole C would be vertically upwards. There would be a slight obliquity to the right in the motion of the upper end of the part immersed, and a slight obliquity to the left in the motion of the lower part; but those obliquities would be so slight that it would take a very solid surrounding to give any very considerable resistance to the motions. It seems to me that after being tried for a time by severe forces pulling in the direction of the arrow-head in the diagram, the left-hand pole would become loose, and would then have only its own weight with which to give stability to the structure; and as the same thing might happen to the other pole by forces in the other direction, the whole is, in point of fact, an arrangement as if devised in the first place to lessen the hold of each pole upon the earth, and afterwards to pluck out one or other, according to the direction of the final pull. It is easy to reckon how much stability will be given by weight, and I believe the virtual stability of this arrangement will be that of two loose poles standing simply by their own weight. I suspect that in truth there would be less resistance in the case of the two poles rigidly connected, as shown in the diagram, than there would be if they were quite independent, with merely a loose link at the top, to give a resistance equal to the sum of the resistance of the two poles separately. I think it very probable that, even taking into account the assistance which gravity would give, it would be found that the particular arrangement shown in the diagram would have more power of resistance to a force applied at the top in a direction perpendicular to the plane of the diagram than

to a force in the direction shown by the arrow-head.

In reply to Mr. Culley,

The President further said—If the force was always in one direction, then there would be nothing to loosen the pole B A. The pole B A would give its full resistance. I think that if there were forces sometimes in the one direction and sometimes in the other, it is even possible that there would be less resistance with the two poles than from the one alone, from the fact that the pole A C would get loosened by forces acting in the direction of the arrow-head. It seems to me that after both poles become loosened, the resistance might be less than with a single pole. If the force is always in one direction (as that shown by the arrow-head), then, with the poles loosely joined at the top, the resistance would be greater undoubtedly than with a single pole; but probably not quite so much greater as double. Although that is not a good arrangement, it would be better than the arrangement shown in the diagram. I think that if the poles were close side by side, there would be less than double the resistance of one pole, because the whole amount of the resistance of the earth that one pole would experience would be diminished by the presence of the other. If the two were placed at a considerable distance from one another, and if they were not coupled so as to give the leverage action upon which I have commented, then the force would still be not quite equal to the sum of the two because the whole force could be distributed exactly on the two poles in proportion to their maximum resistances. The leverage action in the ordinary hammer fork for drawing nails is almost precisely the same in principle as that which I have indicated in this case. I have listened with very great interest both to Mr. Gavey's paper and to the comments, and also to the general information with which other speakers have followed it up. Although it is quite clear that in distant countries, and in a variety of soils, and in circumstances in which division of labour, and minute subdivision of appliances are not available, the method of making holes by the pick and spade is that upon which most reliance must be placed. Still I think that Mr. Gavey has made out an exceedingly good case for the borer in a very large class of applications. What Mr. Culley has said with reference to the trials that have been made shows that there is a large province still left for the borer. It must be remembered that the method is comparatively new, having been in use only a few years; and when so much can be said in its favour as Mr. Culley has said, and as has been brought forward in the paper, I think we must agree that it is a very important appliance. In a large district of country, over which a great many lines of telegraph may have to be taken, and where the soil is generally of a suitable character, the borer will be of considerable value. There can be no doubt whatever of the figures which Mr. Gavey has put before us, and they show a very great increase in the quantity of work done by the labour of a certain number of men through the use of the borer in favourable circumstances. The advantage of bringing forward and describing new appliances before this society is well illustrated by the interesting information and new ideas which we have received from Mr. Gavey himself, and the light which has been thrown on the subject by the different speakers. I propose a cordial vote of thanks to Mr. Gavey for his paper.

The London Stock Exchange is about to be placed in direct telegraphic communication with the Paris Bourse, and the new telegraph station in Paris has just been inspected by the officials of the Submarine Telegraph Company.

Notes.

The new Postmaster-General for the United States, Mr. Jewell, has himself been a practical telegrapher, and a successful business man. He has spent much time in Europe examining the working of the various postal systems. It will be interesting to observe the course he takes on the telegraph question, for his predecessor and President Grant have both urged on Congress the establishment of an American Postal Telegraph system. The proposal, however, met with the most strenuous and successful opposition. Mr. Jewell reports himself as opposed to having the Department go outside of its legitimate functions, and by inference is opposed to the Postal Telegraph system.

We have much pleasure in announcing the fact that Messrs. Siemens have appointed Mr. F. C. Webb (Memb. Inst. C.E. and Soc. T.E.) to succeed the lamented Mr. Ricketts, in charge of the submersion and repair of their cables on the South American coast. Mr. Webb's experience in this particular branch of the profession is perhaps more continuous and extensive than that of any living engineer.

The Queen, who has felt the deepest sympathy for the sufferers by the wreck of the *La Plata*, directed inquiries to be made after the widow of Capt. Dudden, the commander of the vessel. Under present circumstances it is impossible to communicate this expression of Her Majesty's sympathy to Mrs. Dudden. She was married less than twelve months ago, and has just been confined. The news of the loss of the ship and the death of her husband has hitherto been withheld from her, and she will not be told of them until after her recovery. She will at the same time be informed of the admiration Her Majesty feels for the courage displayed by her late husband. The owners and charterers of the *La Plata* have expressed their intention to provide for the support of Mrs. Dudden, should such assistance be necessary. Capt. Palmer, of Her Majesty's ship *Fisgard*, in reply to a question put to him by Messrs. Siemens, has written as follows:—"'Rope Yarn's' letter in *The Times* of December 12 is utterly false with regard to any remark of mine. I never saw the *La Plata* to my recollection, and am not, therefore, likely to have made any remark on her state." Moreover, the *La Plata* never passed the *Fisgard* at all. Messrs. Siemens Brothers state that the dead-weight capacity of the *La Plata* was 1656 tons, and that she had taken on board 184 nautical miles of cable, weighing 765 tons when wet, besides land line materials, 79 tons; buoys, chains, ropes, &c., 55 tons; and machinery, 36 tons; making a total of 935 tons, thus leaving a capacity for coal of 721 tons. They add that—although it would have been greatly to their advantage to save both the delay and the expense involved in coaling at foreign stations, only 266 tons of these 721 tons of coal were placed on board,—the amount, according to Capt. Dudden's opinion, calculated to put the ship in the best possible trim for a voyage during rough weather across the Bay of Biscay.

Upwards of 1200 telegrams, or an average of more than 200 a day, were disposed of in the travelling telegraph office which was stationed in the centre of the Agricultural Hall during the

recent Smithfield Club Cattle Show. On two successive days upwards of 250 telegrams were forwarded and received, and the total number dealt with in the week represents one telegram for every hundred persons who visited the Show. As many as 5000 letters and newspapers were also posted at and delivered from this office during the week. The telegraph van is one of the most useful and successful introductions of Mr. Scudamore.

Telegraphists must have seen with pleasure the effective aid which telegraphy has given to those astronomers who have undertaken to observe the transit of Venus. Practically the whole earth has been made one huge observatory. By its means stations have been selected, longitudes determined, results recorded, and we now know exactly where success has been obtained and where failure has attended the zealous observers. The telegraph has enabled the world of Science to congratulate itself upon a grand triumph.

Electrical Science in English and Foreign Journals.

Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences, Vol. lxxix., No. 21. November 23, 1874.

On Fresh Improvements upon Magneto-Electric Machines.—Z. T. Gramme.—Compared with his model of 1872 his new model for this year possesses many advantages. This galvanoplastic machine has now only one central ring instead of two, and two bar electro-magnets instead of four. Its weight is 177 kilogrms., that of the copper ring and the electro-magnet bars being 47 kilogrms. The dimensions are—0·55 m. wide, 0·60 m. high. In comparison with his 1872 model this last one possesses the following advantages:—(1.) Half the size. (2.) Three-quarters the weight. (3.) The copper used in its construction reduced to three-quarters. (4.) The motive force necessary to work it is much reduced. These improvements are obtained by the suppression of the exciting bobbin; by putting the electro-magnet in the circuit itself of the current; by a better arrangement of the copper portions of the electro-magnet bars; and by a slight increase of speed. "The electro-magnet setting, which I used to make with round wire, is now formed of a band of thin copper half the width of a bar magnet. The arrangement of putting the electro-magnet in the circuit has given rise to a change of pole, which I have been obliged to cancel. When the machines are in motion, and the circuit closed by metallic baths, the poles remain the same; but as soon as a catch or a stoppage takes place, accidentally or by design, the poles change, so that if the machine be again put in motion without re-arranging the conductors an *inverse* work will be performed. For example, instead of silver-plating the objects for the bath, they will be unsilvered. To obviate this inconvenience I cause the current to be cut off automatically as soon as the machine slackens, and thus avoid secondary currents, which alone occasion these polar reversals. Similar improvements in construction, and very considerable reductions in weight and size, have also been effected in electro-magnetic lighting machines, whether for lighting gas-lights or lighthouses."

No. 22. November 30, 1874.

Quite void of any papers touching on electrical, magnetic, or telegraphic subjects.

Les Mondes. Vol. xxxv., No. 13. November 26, 1874.

The Pneumatic Telegraph: a Way to Discover where Carriers are when Stopped in the Tube.—M. Pouchet, in the *Revue Scientifique du Siecle*, says:—Although this accident is exceedingly rare, yet the possibility of its happening at all necessitates the discovery of a ready means for localising the position of the arrested carrier. The method hitherto employed has not given good results. It is to apply to the mouth of the pneumatic tube a receptacle full of compressed air of a known pressure, which is allowed to enter the tube. The resultant pressure in the receptacle and the tube as far as the arrested carrier furnishes datum to estimate the carrier's distance. The distances so measured have not even been approximately correct. M. Ch. Bontemps adopts another method based on the law of the propagation of sound-waves in pipes. He fits to the mouth of the pneumatic tube a kind of drum,—an instrument furnished with an elastic membrane whose inflations or depressions are automatically registered upon a revolving cylinder. A diapason likewise traces, upon the same cylinder, seconds and fractions of a second. The under part of the membrane is set in motion by an explosion, say that of a pistol. The blow raises the membrane, and its upward motion is at once registered. The wave speeds onwards along the tube with the speed of 330 metres a second, and strikes against the obstacle; thence it is reflected back to the membrane, and a second motion is registered. It now only remains to calculate the exact time between the two registers, representing twice the time the wave takes to traverse the distance from the tube's mouth to the obstacle. This arrangement is said to be so exact that the possible error does not exceed 2 metres.

Nos. 14 and 15. December 3 and 10, 1874.

Nothing is published in these numbers suited to our readers, except what we have already translated from other scientific journals.

Bulletin de la Société d'Encouragement pour l'Industrie Nationale. December, 1874.

Description of MM. Voisin and Dronier's Electro-Catalytic Lamp-Lighter.—A full description of this apparatus was sent to us by the Count du Moncel, and appeared in our number for last June, page 225.

Annales Telegraphiques. Third Series.

This is the reappearance of an old and well-known serial. The first numbers were issued in 1855, by the late M. Emile Saigey, then Inspector of the telegraph lines, and after a short life of eight months the publication was discontinued. In 1858 it was resuscitated, under the superintendence of a Committee, soon to suffer another interruption towards the end of 1865. For the third time the publication is now re-commenced as a *third* series.

To Correspondents.

Mr. Charles B. Sharpe's communication respecting the invention of the Electric Telegraph is not in such a form as to enable us to publish it. His statements must be supported by printed and published evidence.

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THE TELEGRAPHIC JOURNAL.

Vol. III.—No. 47.

FARADAY.

Dr. Gladstone's lectures at the Royal Institution have forcibly brought into prominence that "great and good man," Faraday. Lecturing from the same table that he lectured from, using the same apparatus that he used, illustrating the very discoveries that he made in that very place, it was impossible for the lecturer to avoid frequent reference to that illustrious philosopher. Every mention of his name was greeted with a round of applause from the demonstrative juveniles present, showing that the knowledge of the good he had done was well known to those who never could have heard him, while from those that had heard him, and had listened to his clear and lucid descriptions, a grateful cheer testified to their appreciation of the just tributes paid by the lecturer to his memory.

Faraday's whole character is a pattern to all young aspirants to scientific fame. The son of a poor blacksmith, the apprentice to a bookbinder, rose, by steady perseverance, determined application, and sterling worth, to be one of England's greatest scientific worthies. His motto was "experiment." He interrogated Nature in every conceivable form. Experiment was to him the great test of truth, and he accepted no fact until it was confirmed by observation and experience. Thus, in the severe cross-examination he gave Nature, he discovered those various forms of electricity and properties of matter which have made his name immortal. Foreigners, more demonstrative than his own countrymen, have named his great discovery—magneto-electricity—*Faradaism;* and in medical phraseology the term *faradisation* is creeping into use in contradistinction to galvanisation—the one being the effect produced by the intermittent currents of magneto-electric induction, and the other the constant influence of voltaic currents. His views on the nature of electricity, and the way in which electrical action is propagated by molecular action, have not yet received general acceptance abroad, though indications exist that his ideas are gradually percolating the scientific schools of the Continent.

His researches are a model of method, system, and order. They are out of print, and very scarce. No electric library should be without them. No student should be satisfied until he has read them. It is strange that some enterprising publisher does not republish them. They are full of the simplest and most beautiful experiments; and though the flights of his genius have frequently taken him to prophetic and seer-like views, beyond the comprehension of the tyro, the descriptions and explanations are generally so clear and exhaustive that they carry conviction with them.

Tyndall wrote of him:—"The fairest traits of a character sketched by St. Paul found in him perfect illustration; for he was 'blameless, vigilant, sober, of good behaviour, apt to teach, not given to filthy lucre.' He had not a trace of worldly ambition; he declared his duty to his sovereign by going to the levée once a year, but beyond this he never sought contact with the great. The life of his spirit and of his intellect was so full, that the things which men most strive after were absolutely indifferent to him. 'Give me health and a day,' says the brave Emerson, 'and I will make the pomp of emperors ridiculous.' In an eminent degree Faraday could say the same. What to him was the splendour of a palace compared with a thunderstorm on Brighton Downs? What amongst all the appliance of royalty to compare with the setting sun? I refer to a thunderstorm and a sunset because these things excited a kind of ecstacy in his mind, and to a mind open to such ecstacy the pomps and pleasures of the world are usually of small account. Nature, not education, rendered Faraday strong and refined. A favourite experiment of his own was representative of himself. He loved to show that water in crystallising excluded all foreign ingredients, however intimately they might be mixed with it. Out of acids, alkalies, or saline solutions, the crystal came sweet and pure. By some such natural process in the formation of this man beauty and nobleness coalesced to the exclusion of everything vulgar and low. He did not learn his gentleness in the world, for he withdrew himself from its culture; and still this land of England contained no truer gentleman than he. Not half his greatness was incorporate in his science, for science could not reveal the bravery and delicacy of his heart.

"But it is time that I should end these weak words, and lay my poor garland on the grave of this

'Just and faithful knight of God.'"

The number of messages passing over the Cuba Submarine Telegraph Company's line during the month of December, 1874, was 2073, estimated to produce about £2300, as against 726 messages, producing £742 in December, 1873.

The traffic receipts of the Western and Brazilian Telegraph Company (Limited) from the 20th November to the 25th December (five weeks) were £12,764 17s. 4d.

The receipts of the Submarine Telegraph Company for the month of December, 1874, were £7895 10s. 4d.; those for the corresponding month of the preceding year amounted to £7933 19s. 8d.

THE VOLTAIC BATTERY.

A Course of Six Lectures,

By Dr. JOHN HALL GLADSTONE, F.R.S.,
Fullerian Professor of Chemistry, Royal Institution.

Delivered at the Royal Institution of Great Britain.—Christmas, 1874-5.

Lecture I.—The Cell and its Effects.

Ladies and Gentlemen,—I am glad to see that this room is so well filled; but while I thoroughly welcome all of you elders, who have done me the honour of coming to hear the lectures, it will be understood that I address my lectures especially to the juveniles who occupy the front rows of seats, and I shall endeavour to confine my thoughts as much as possible to them.

And now, girls and boys, I want to bring before you this subject of the voltaic battery in such a way that you can understand it, and can repeat the experiments, as far as they lie within your power. I shall endeavour to perform various experiments with such simple means as you may find in your own homes, or which you may buy at a small expense, so that when you go home you may repeat them for yourselves. You will, in that way, learn a very great deal more than from any amount of listening to me, and you will thus get experience for yourselves, and grow up young philosophers.

I want, first of all, then, to show you how we can produce the thing which we call the voltaic force, or galvanism, or dynamical electricity. I shall produce it by means of three very common things —copper, zinc, and sulphuric acid.

With copper you are all familiar. Here are specimens of copper of different sorts. You know it as this red metal, which is capable of being drawn out into wire, capable of being hammered into various forms, and worked up into different articles. Here is some Japanese copper, of a somewhat different colour. I need not enter upon a fuller description, because you know the metal very well.

As for zinc, you may not be so familiar with it; but here are different forms of the metal. You will observe it is a greyish-white metal, not so white as silver, but whiter than lead. Here is some in the form of sheet zinc. This, again, has been dropped into water, so that we have it granulated; or we may have it in the form of beautiful crystals. It cannot be drawn out into wire or hammered out like copper, for it is a much more brittle metal. When this crystalline form is struck, you see how it breaks from one side of the block to the other. Probably you are most familiar with zinc through its being used for chimney-pots which are put up for curing smoky chimneys, and for purposes of that sort.

Well, then, we take these two things,—copper and zinc,—and we take a fluid with them. We cannot get on at all without a fluid body, and one that consists of two parts. I take sulphuric acid; here is some in this bottle. It is a heavy liquid, having nearly twice the weight of water. It is a thick liquid, for, if I shake it, you see that it looks oily, and the bubbles take a long time in rising. This is very different from water. In fact, there is no water, or very little water, in the bottle. This liquid is very corrosive. You can get it at the chemist's, and it is one of the cheapest things that are sold; but you must be careful how you use it. You see how it corrodes things. I will pour some of it on this piece of wood, and we shall soon see that the wood will be stained. Then suppose I take a little sugar, instead of wood: here is some sugar which has been already dissolved in water, to save time. We pour the sulphuric acid into the solution of sugar, and we shall find that we get an effect. [The solution became black and greatly swollen upon the addition of the sulphuric acid.] You see how violently the sulphuric acid acts upon the sugar. Here is a cloth: you will see the corrosion on the cloth when I pour sulphuric acid upon it. It does not become precisely black, but you see what a destructive effect the acid has. That is the sort of effect often produced upon the cloths which we use in our laboratories, and I wanted to show you the experiment in order that you may be careful not to get the sulphuric acid upon your clothes, or upon table-cloths or furniture. I have no doubt that those friends who occupy the upper benches of this place will be better pleased by your experiments if you reduce as few towels to this condition as is convenient. If I were to mix the sulphuric acid with water it would produce a considerable amount of heat. I will show you that. I will take about equal parts of water and sulphuric acid. I am the more desirous of showing you this effect, because it will be necessary that you should add water to the sulphuric acid when you experiment with it yourselves. I have poured the two liquids together, and the glass has become very warm. You see, when I wet it, how it steams. In fact, it is so hot that I cannot bear my hand upon it for any length of time. I suppose that the heat of the mixture is now about that of boiling water.

Suppose we take some of this metallic zinc and sulphuric acid, and put them together; what do we find? Here is the metallic zinc; I will add to it the sulphuric acid, and you will soon see that something takes place between the two. There is a movement, and there are bubbles formed which will speedily rise; they consist of hydrogen gas. This gas is lighter than the atmosphere, and therefore ascends very rapidly, and, in fact, it will take up with it any light object. There is some being produced in this vessel, and we will inflate this balloon with it. As the operation will take some little time, I will begin to inflate the balloon now. This gas will take fire very easily, and will burn with a slightly luminous flame. I do not want to set fire to it too soon after it begins to bubble up; and I will warn any of you, who make this experiment, against applying the light before all the air is driven out. The reason is that, in such a case, the apparatus will blow up. That is what constantly happens with young experimenters when they are dealing with hydrogen. You see I can now ignite it, and there is the gas burning away. Now, instead of burning it in that manner, I will collect some of it in this vessel, and we shall soon have a large quantity of it. In the meantime our balloon will be filling. I might show you that hydrogen is a light gas by turning it from one vessel to another, if I pleased; and you would see that I should have to pour upwards, instead of pouring downward as you pour most things; but time presses, and I will not show you that. [A jar full of hydrogen was

collected over water, and then removed from the trough.] You see I can lift up the gas in this way, and carry it about where I please. I will set fire to it, and now, you see, I can pour the gas out by turning the mouth of the jar upwards, and pour the flame up into the air as the gas ascends.

The balloon which I showed you just now is already filled with gas. The hydrogen is capable of carrying the balloon up into the air, and no wonder, as it is nearly fifteen times lighter than air. I mean to keep the balloon captive, for if I were to let it go it would probably find its way into those lamps, and then we should have a combustion on a very large scale. The hydrogen is capable of carrying not only the balloon itself, but the piece of india-rubber tube that is attached to it, and by which the hydrogen was put into the balloon.

We find, therefore, that if we take zinc and put it into sulphuric acid an effervescence takes place; there are a great number of bubbles produced, and these bubbles are not bubbles of air, but of this very light gas, hydrogen, to which we can set fire. But now I want to show you that not only has gas been produced, but something else has been formed at the same time.

I omitted to speak of one property which zinc has, and in which it differs from copper. It is difficult to set copper on fire. I do not say that we chemists cannot do it, for we can do a great many strange things; but we can very easily set zinc on fire. I do not say that it will burn as easily as paper or wood: but if I throw little pieces of zinc into the fire you will see that they will burn. Mark that beautiful flame which is rising in the fire; that is caused by the burning of the zinc. Here are some zinc shavings mixed with wooden shavings, to make them catch more easily. We will set light to the wood shavings, and then blow upon the mixture; we shall thus make the zinc burn. I draw your attention to these white clouds of smoke rising from the burning zinc. You see the beautiful colour of the flame. These white masses of smoke which are rising in the air consist of a combination of zinc with the oxygen of the air. The compound thus formed is oxide of zinc. It is falling down as a kind of permanent snow,—not like the snow that is outside this building, but a snow which will not dissolve. I dare say that it is falling down upon you in various parts of the room. You will bear in mind, then, that this is white oxide of zinc.

Now I will take the vessel in which the zinc has been dissolving in sulphuric acid. The vessel has become so hot that I must take it up with a cloth. I will pour a little of the liquid out, and what I shall find is that some zinc has dissolved in the acid. I will not show it to you as zinc, but as that white oxide—the same sort of thing as was floating about in the air just now, after the zinc shavings were burnt upon the table. Here I pour in some potash in order to take away the acid, and you perceive some white stuff floating about in the liquid; that is oxide of zinc. The liquid has now become quite thick, with this white oxide suspended in it. If I had taken some of this liquid and poured it off into a basin, and put it over a lamp and evaporated off the water, we should have obtained a crystallised salt called sulphate of zinc. When you look at it from a distance it is something like common salt, but when you come to look at it more closely you will see that it is quite different in its crystalline appearance, like the fine specimen on the table.

We thus have seen what takes place if sulphuric acid and zinc are put together. Now suppose that instead of taking sulphuric acid and zinc, I take sulphuric acid and copper. Here is a sheet of copper; I put it into the acid, and what happens? I do not know whether any of you can see anything happening; I cannot. The fact is that if the two things are perfectly clean nothing at all happens. The copper and the sulphuric acid have nothing to say to one another whatsoever. You know very well, from what I have shown you, that if I had put a plate of zinc into the sulphuric acid we should have seen an action at once set up, and there would have been little bubbles of hydrogen gas floating from the zinc. I will now put the plate of zinc into the acid with the copper, and I thus get together the three things which I want. I get the copper, the sulphuric acid, and the zinc in the same vessel; but at present, as they stand, the zinc is dissolving away through the action of the acid, and the copper is doing nothing at all. But if I cause them to touch, either under the water or above the water, or in any sort of way, then we see that bubbles begin to come upon the copper as well as upon the zinc. I have now made them touch under the water, and I see the bubbles coming upon the copper in great quantities. Supposing that I did it in another way, and that, instead of causing the two metals to touch together under the water, I were to make them touch by means of a wire, or any other piece of metal, above the water. Here is a pencil-case; and if I cause it to touch the two metals, I still find that the bubbles will come upon the copper just as much as when the copper and the zinc were touching together below the surface of the water. But the copper is not dissolved at all. It is the zinc that is dissolving, although the bubbles come upon the copper. This appears still more if I take some zinc which has had mercury rubbed over it. You can easily cover the zinc with mercury. Take a little mercury, and rub it over the zinc, and that will cause the zinc to last much longer, and to be much more satisfactory. If we put this zinc which has been covered with mercury into sulphuric acid, it does not dissolve; but if I touch it with copper we shall find streams of bubbles coming from the copper.

Here, by means of this arrangement, we get a cell for the first time. This is a simple cell, made of the most simple materials that I can bring together, and which cost next to nothing; and you can repeat the experiment very easily. You must add to the sulphuric acid a good deal of water,—perhaps six or eight times its own bulk. You can make use of any glass, such as a tumbler, for the purpose of the experiment. Look at it carefully, as it is passed round the room. Of course you must take care, as I have told you, not to get the sulphuric acid upon your clothes, or upon your gloves. I want to show you this cell on a larger scale, so that you may all have the advantage of seeing it together. Here I have a large vessel containing dilute sulphuric acid. I will first place in it a piece of common zinc, and, instead of your seeing it by means of the ordinary daylight, we will throw on it a beam from the electric lamp, and then you will see the effect very clearly. We must

have darkness in the room, in order that you may see the experiment properly. You will now see, on a large scale, just what you saw in the little tumbler which I used at first. I want to make a battery of this large vessel. We have now got a good stream of light upon it, and I will put the plate of zinc into the sulphuric acid. You will see that there are bubbles of gas coming upon the surface of the metal. Presently they will become more evident. There they are. Now they are getting scattered throughout the water at a distance from the zinc. Suppose I were to take this plate of copper, and place it in the vessel. The light is now shining upon the copper, and you can see that there are no bubbles upon that metal, or, at least, there are none worth speaking of,—certainly no stream of bubbles. I will now bring the two plates into contact, and you see that the copper at once becomes white, in consequence of the great number of bubbles that flash from it. There you see a stream of bubbles pouring up from the copper, especially from that end of it which is nearest to the zinc. I will now take the copper away from the zinc, and you will soon see that the bubbles all disappear, and will not come again. I will now remove this zinc plate, and put into the cell a plate which has been amalgamated,—that is, has had mercury rubbed upon it. You will now see that, in the first instance, no bubbles will come upon the amalgamated plate. There it is, in the strong beam of the electric light; but, close as I am to it, I see no bubbles, excepting a few that have been floating about the liquid. Just a few bubbles have now formed upon one edge of the plate. I do not know why that has happened, but probably the plate had not got properly amalgamated there. If I touch the zinc and the copper plate together, bubbles will come upon the copper at once. I have now made the two plates touch together near the bottom, and you see how bubbles at once come upon the copper. Suppose I touch them above the liquid instead of under the liquid, still the bubbles come on the copper at once, though the copper is a long way from the zinc. Suppose that, instead of actually touching the plates themselves, I join them by metal in some other way. I will presently join them by means of a wire; but, first of all, let me take any straight piece of metal, without any mystery about it, and join the plates together by means of it. Bubbles at once flash upon the copper directly the piece of metal touches both plates. The same thing happens if I join the two plates by means of a wire. I will now join the plates,—I was going to say in a more scientific way, but that would be wrong, for the simpler a method is the more scientific it is. I will now, for convenience sake, put upon the plates of metal binding-screws, by means of which we can hold anything to the plates very easily, and which we shall find very useful as we go on. I put a binding-screw on each plate, and attach wires to them. At present these two wires are not joined, and there are no bubbles, but directly I join the wires white bubbles of hydrogen appear, and whiten the copper plate as before. There they are. I now cease to join the wires, and the bubbles will go off. I now want to show you a few things that happen when these wires are brought together. I do not know whether you can see little sparks at the ends of the wires when they are brought together; but I can see them. It requires to be rather near in order to see the sparks, but I dare say there are a great number of bright eyes in the room that can see them. If any little boys or girls would like to come and see the sparks, they can be the spokesmen to the others of what they have seen. You may notice that the sparks occur when one wire is caused to touch the other, and is then separated from it.

We will now let that cell go working on, and we will make it do something else. I have here a magnet, and I can cause these wires to alter its position. The magnet is lying along under this wire. It is very easy to make this instrument. You can take any little magnet that is easily suspended, as this is, on a needle driven through a board, and stretch over it a piece of wire lengthwise. There is a piece of blue paper on one end and a piece of red paper on the other, so as to show the two opposite ends of the magnet. It is lying quite steady at present in the meridian of north and south. I am going to make the wire of the cell part of the wire attached to the magnet. Directly I bring the two wires together, away goes the magnet, and it does not swing back again in a hurry. It has been set swinging by the current that has gone through the wire, and it comes to rest in a different position. If I break the wire, the magnet goes swinging back again to its first position. I will now let it come to rest a bit, and we will see what more I can do with it. You recollect that I made the blue end swing in a particular direction. I will now take the wires of the cell and join them to the opposite ends of the wire over the magnet, and you will see that the blue end will swing round to the other side. Thus you see that one effect that we can get is to turn a magnet out of its position, and we have done that by means of our single cell.

We will now take a piece of iron, which is not a magnet, though it looks like one. It is a piece of iron in the form of a horseshoe, and with wires twisted round it, such as you can buy in any philosophical instrument maker's shop very readily. I said that it was not a magnet. You see that it does not attract iron. It will not hold this "keeper" at all. But now I will make the wire which is twisted round it join with the wires from the cell, and we shall see what happens. We now find that the piece of iron has become a magnet. It will now hold this weight very well, and I hardly know how to get it off again. I dare say it will hold other weights besides. Here is a seven-pound weight. Let us see whether it will hold it up. It will scarcely hold so large a weight as this; but it will hold up this one (a four-pound weight). You see I have turned this piece of iron into a pretty powerful magnet, by just joining the wire which is round it with the wires from the cell.

There are other effects which this cell will produce. I may handle these two wires with perfect impunity. You see I take these wires in my hands, and I am not at all afraid of getting any shock upon my body in that way. But still I could produce certain effects upon the body with these wires. For instance, if I were to put them around my tongue, which is more sensitive, I should get a very peculiar taste. I do not say whether it is an agreeable or a disagreeable taste. I have had a number of pieces of zinc prepared here, so that you may have some of them, and try the experiment

with them afterwards. You take one of the little pieces of zinc and a silver coin, put them on each side of your tongue, and allow them to touch, and you will get the same effect as with these wires. You may try that experiment afterwards at your own pleasure if you like to take away some of the pieces of zinc.

Now I want to take these wires, and do another thing. I will make them broad at the ends, and for this purpose I will take another metal—platinum. It is necessary that I should employ platinum in this case, though it does not give any new galvanic effect; and you may consider, therefore, that I have made the copper wires broad at the ends by joining these pieces of platinum. We have poured upon this paper a solution of iodide of potassium and a little starch. Now iodine has the peculiar property of turning starch blue; and if we can set free the iodine from the iodide of potassium we may expect to see the blue colour. Let us see whether that cell is able to separate the iodine from the potassium. I place the two wires one upon another; but there is paper between the two, and there is no contact—at least, there is only contact through the liquid itself. Now let me separate the two from one another, and see what we have. There is the mark of this platinum plate in blue upon the paper. We have, therefore, effected a chemical splitting up, or chemical decomposition.

Here, then, we have various effects produced from our one cell. I have taken merely one plate of zinc and one plate of copper, and dipped them into weak sulphuric acid, and you see what we have obtained. We have got this strange transference of the hydrogen from one plate to the other. It is the zinc plate which dissolves up; but the hydrogen appears upon the copper plate. But we have effected more than that. We have produced the little sparks which some of you saw; we have caused the turning or "deflection" of the magnet; we have made a piece of soft iron into a magnet, and we have decomposed some iodide of potassium, so as to split it up into potassium and iodine. There are one or two other things that we could have produced if we had had a more powerful cell than that. I will now take a more powerful cell, or, rather, I will take a number of cells. I am not going to show the cells here, and I am not going to use a great number of things as big as the cell which I have been using; but I shall make use of a great number of cells of a more powerful kind, and which form what we call a battery. Here is one lot of them containing five cells; and we have two or three little arrangements of that kind about the house, with wires coming up from them; and by this means I can turn on a great deal more power than I had before. Instead of employing one large cell, as I have been doing, we can take several cells, and cells of greater power.

Now let us see what effects we get with these powerful cells. First of all I should like to show you something which I did not show you before. We will take a long piece of platinum wire. Here are two ends of wire which I can tie together; and here are some iron filings. I can get this wire covered with iron filings, which will stick to it, and I can thus turn these filings into little magnets. Now I break contact, and the filings drop off, just as the weights dropped off the magnet. I will now take these long wires and twist them round these stands, so as to make these stands part of my wire. You must know that when I am talking of a "wire" I do not mean merely what you commonly call a wire; but if I put on any piece of metal between the wires I call that piece of metal a wire. It is, in my eyes, part of the wire which runs from one plate to the other. I now join this platinum wire on between the two wires, and there you see the current going through. The current has made the platinum wire red hot, and although there is the usual light in the room, you can see how bright the platinum has become. We will make the platinum wire a good bit shorter, and I daresay that we shall find it still brighter than it was before. It has now reached a white heat. Let us have it shorter than that. There, the current has now actually melted the platinum wire, although platinum is one of the hardest of all the metals to melt. Now, instead of taking a platinum wire, I will take an iron wire. The iron becomes red hot; now it is broken, and the iron is actually burning and blazing away on the table. You thus see what a heat we can produce by means of this battery by passing the current through thin wires.

But, beside this intense heat, I want to show you other effects which we can produce. I should like to show you some more of those magnetic effects. Here is a little magnet which is capable of being moved, and we can send a current through it by taking part of it into the wire of our battery, and when we do that we shall find that the magnet itself will move. You see, away it goes spinning round and round. We are actually making the magnet rotate through sending a current through part of it in this way. If we were to reverse the position of the wires, we should send it round the other way. We will try. There it goes spinning round in the opposite direction. Here I have a pleasant piece of apparatus by which a shock can be given. I am not going to give you all a shock at this present time; but if any of you like to try it afterwards I can pass the current through a great number of you all at once, and you can all have the pleasure of a shock at the same time; or if any girl or boy is greedy enough to want the whole force of it to himself, he may have as much as ever he likes from this apparatus.

During this course of lectures I shall have to introduce to you several pieces of apparatus worthy of all honour, and this large magnet is one of them. I do not mean that this is particularly valuable because it is very large, but because there are associations connected with it. It is not difficult to get a great magnet like this; you can buy one. But this particular magnet, which belongs to the Royal Institution, is one that has a history and a character. It was made long, long ago, by that great and good man—Professor Faraday; and so you are looking at his great electro-magnet—that with which he did a great deal of his very best work. He used to look at that magnet, and work with it, and imagine the forces which were revolving about it. To a certain extent it is clumsily made compared with the magnets made now-a-days. It is, I believe, formed from one link of an enormous cable cut across, and these wires have been twisted round about it. It is, on a large scale, just like this little magnet of soft iron. We can pass a current from the battery round about this large magnet, and produce much greater effects than we did before.

Instead of being able to hang only a seven-pound weight upon it, I could hang almost any weight I pleased upon the large magnet. I could hang myself upon it quite easily. I will, first of all, take some of these little filings, such as I had just now, and spread them on this sheet of paper by means of a pepper-box. I will scatter them over the surface of the paper which rests on the ends of the magnet. If the power is sent through the magnet we shall see certain effects. I shake the paper, and you perceive how the filings burst into broad lines, and form themselves into ridges, and wander about in various directions. We see that they are arranging themselves, not only on the poles, but are standing up and bending over in various directions. If I turn the magnet down, you see that they do not fall off, although the paper is pretty nearly vertical. They are standing up like a brush. Suppose that, instead of taking little things like filings, I take some of these nails; you will see that they do the same thing. I can pile them up in this way, and make a bridge of them. It is very hard indeed to pull them away. When I look at these things I think of Faraday, of whom I was speaking just now, and I think of his enthusiasm, and how he used to attract little boys and girls, and infuse his own enthusiasm into them, and make them magnets too. These nails become magnets, but after breaking the connection they cease to be so, and fall off; but I hope that in the case of a good man like Faraday the influence remains after he is removed, and that many who have been attracted by him do continue to attract others in their own little way. If these nails were made of steel they would remain magnets, and would retain a good deal of their magnetism when the contact was broken. Even so I hope many of you may be permanent magnets.

I will now take a common poker and turn it into a magnet. If you have a voltaic battery you can do that for yourselves. We are going to try it with a strong battery, and you will see that the poker round which this protected wire is coiled is turned into a magnet; and I dare say that we shall be able to pick up any of these nails with it. You see that the poker, when thus made into a magnet, is able to take up the nails, and each nail is turned into a magnet itself, and attracts others, so that the power is communicated from one to the other; but if the contact is broken, off these nails fall again.

I just now spoke of the spark. I shall not show you the electric light just now, for I must reserve all I have to say about that until another time, when I hope to do justice to it. Neither will I show you any more decompositions to-day, for I am going to devote a whole hour to the subject of experiments of that kind; but I wish to show you the spark going through rarefied gases. The spark, as we have already seen it, goes through the common air; but if it is made to go through rarefied gases it will have a different appearance. While that is being prepared here are two pieces of coke just taken up from the grate, and we will make the spark pass through the air between them. You see the intensely brilliant light which is produced in this way. It is a light rivalling the sun itself.

Mr. Ladd has now arranged an experiment by which we shall see the spark as it goes through rarefied gases :—In the glass tubes before you there are certain gases and certain liquids which have a peculiar optical property, and which take up the electric light and send it forth again. We will now cause the current to pass. [Various brilliant effects were produced by means of vacuum tubes.] This light is not only a beautiful lambent, coloured light, flowing in masses and clouds through these tubes, but it is broken up into various bands and striæ, and it pours from one vessel to the other; but you must see it near at hand in order to estimate its full beauty.

We have now obtained from the single cell with which we started various extraordinary effects. We find substances appearing where we should not expect them to appear; we find that we can produce heat, or sparks, or shocks to our nerves; that we can make magnets, and twist magnets round; and that we can produce a thousand chemical decompositions, if we like, by means of this force. What a wonderful force this is! I dare say many of you boys are well acquainted with the old classic myth of Proteus, and you know that Proteus was said to have many secrets; but if any mortal caught hold of him he would try to elude his grasp, and escape from him as a flash of lightning, or as a tiger, or as running water, or as wind. Now this voltaic power is something like Proteus. We find it changing into these various forms. Sometimes it appears as chemical action, sometimes as heat, sometimes as light, sometimes as a feeling in our nerves, sometimes as magnetism; and what we have to do is to try and get hold of him as Proteus was secured. They had to catch Proteus in his den, when he was asleep, and put a chain around him, and then they could make him tell his secrets. And so we, in our next lectures, will endeavour to trace this force to his den, and so enchain him as to make him reveal his origin and all his mysteries.

FIFTY YEARS' PROGRESS.

Few things in our day have experienced such rapid development as the electric telegraph. It is true that nearly 2000 years ago the keen-sighted, inquisitive Greeks had set about to inquire into the source of that marvellous power which we call electricity, and it is equally true that this invisible force must have existed a long time prior to the inquiries of these ancient Greeks. But the practical application of it, as it exists in our day, is a thing of comparatively recent origin—so recent, indeed, that many of the early disciples of electric telegraphy have lived to witness the realisation of all their hopes, and more. As early as the year 1600 the subject of electricity and magnetism began to engage the attention of thinking men in England and throughout Europe; and to this period belongs the Latin treatise of Dr. Gilbert, of Colchester, which may be said to have been the first really practical work on the subject. Then followed the discoveries of Stephen Gray, a pensioner of the Charterhouse, Du Faye, Franklin, Galvani, Volta, Sir Humphry Davy, Ritter of Munich, Oersted, the celebrated Danish philosopher, Arago, Sturgeon, and Faraday. These, however, had all laboured more or less in the higher field of electrical science; although, as a matter of course, their labours tended in no small degree to bring about the consummation which very speedily followed the important discoveries of Faraday about the year 1830. Prior to this—viz., in 1753—one Charles Morrison, described in the *Scots' Magazine*, under the initials "C. M.," his so-called "Expeditious Method of Conveying Intelligence;" but although his

system may be said to have contained the germ of that now in use, it was so costly, and so little "expeditious," that it required a separate wire for each letter of the alphabet, and practically a separate apparatus for each wire. Morrison's plan was reproduced some twenty years later—in 1774—by one Le Sage, a Frenchman, who submitted it to Frederick of Prussia as an original method of electric telegraphy. But it soon dropped out of notice, both in this country and abroad; and, as is well known, the first really practical telegraphs belong to the year 1837, when Messrs. Cooke and Wheatstone took out their first patent.

The subsequent history of the electric telegraph need not be dealt with here, except so far as it derives additional interest from the perusal of a somewhat curious work published about fifteen years prior to the inventions of Messrs. Cooke and Wheatstone, which probably attracted little notice at the time, and has long since been forgotten. In 1823—just fifty years ago—Francis Ronalds, of Hammersmith, whose labours in the cause of electric telegraphy were as ardent and persevering as they proved disheartening and unprofitable, published for private circulation a little work entitled "Descriptions of an Electric Telegraph," which it is interesting and instructive to read in the light of what has been achieved in regard to telegraphic communication during the past half-century. Mr. Ronalds appears to have been the first to make the experiment, on any great scale, of sending a current of electricity through an aërial wire, which he erected on a "lawn or grass plot" near his residence at Hammersmith. Of course it was impossible to erect any great length of single continuous wire in such a situation; but Mr. Ronalds very ingeniously surmounted this difficulty by erecting two wooden frames, placed at a distance of twenty yards from each other, each frame being traversed by nineteen horizontal bars, and each bar having thirty-seven hooks, from which depended silken cords, supporting and also insulating a small iron wire. This wire, which made its inflections at the points of support, composed in one continuous length a distance of rather more than eight miles; and when it was charged from a Leyden jar, and the shock passed through two insulated inflammable air pistols, the result was, in Mr. Ronalds's own expressive way of describing it, that "three of the senses—viz., sight, feeling, and hearing—seemed to receive absolute conviction of the instantaneous transmission of electric signs." We need not follow Mr. Ronalds through his detailed account of the experiment; but the impression which it seems to have made on his mind, although recorded in somewhat crude and homely language, is remarkable as foreshadowing very closely indeed what has come to pass since then. He says:—"The result seemed to be that that most extraordinary fluid, or agency, electricity, may actually be employed for a more practically useful purpose than the gratification of the philosopher's inquisitive research, the schoolboy's idle amusement, or the physician's tool; that it may be compelled to travel as many hundred miles beneath our feet as the subterranean ghost which nightly haunts our metropolis, our provincial towns, and even our high roads; and that in such an enlightened country and obscure climate as this its travels would be productive of, at the least, as much public and private benefit." "Why," he asks, "has no serious trial yet been made of the qualifications of so diligent a courier? And if he should be proved competent to the task, why should not our kings hold councils at Brighton with their ministers in London? Why should not our Government govern at Portsmouth almost as promptly as in Downing Street? Why should our defaulters escape by default of our foggy climate? and, since our piteous *innamorati* are not all Alphei, why should they add to the torments of absence those dilatory tormentors, pens, ink, paper, and posts? Let us have electrical *conversazione* offices, communicating with each other all over the kingdom, if we can." It would hardly be possible at the present day to describe more accurately the progress of electric telegraphy than in these characteristic sentences of Mr. Ronalds. We have "electrical *conversazione* offices" all over the kingdom. The wires which practically connect Balmoral, Windsor, and Osborne with Downing Street, enable Her Majesty to "hold councils with her Ministers in London" at any momoment; and the extensive system of Admiralty and War Office telegraphs enables the Government to "govern at Portsmouth (and many places besides) "as promptly as in Downing Street." One of the very first acts of the very earliest telegraph was the capture of Tawell, the Quaker murderer; and the curious ramification of police telegraphy in London, if not an absolute protection against our "foggy climate," is at least a terror to those who might otherwise elude the grasp of the law. As for our "piteous *innamorati*," it is perfectly well known that they use the wires as freely as most people, and that "love telegrams" are gradually taking the place of "love letters."

But, besides foreshadowing many of the uses of the telegraph, Mr. Ronalds has placed on record in his homely treatise many practical suggestions as to its construction and maintenance which are actually being followed—unconsciously, perhaps, for his is no textbook of the science—at the present day. His back garden at Hammersmith appears to have been the scene not only of one of the earliest aerial telegraphs, but also of the first experiment with an underground line. He tells us that "a trench was dug in the garden 525 feet in length, and four feet deep. In this was laid a trough of wood, two inches square, well lined inside and out with pitch; and within this trough thick glass tubes were placed, through which the wire ran. The trough was then covered with pieces of wood, screwed upon it while the pitch was hot; they also, in turn, were well covered with pitch, and the earth then thrown into the trench again." Mr. Ronalds goes on to describe his method of signalling through this experimentally perfect line; and also gives the outlines of a "telegraphic dictionary," by means of which a word, or even a whole sentence, could be conveyed by only three discharges of the wire in a mean space of 54 seconds. Even at such an early stage of telegraphic development, Mr. Ronalds was by no means insensible to the *sine qua non* of a perfect telegraphic system; for he gives it as his opinion that a signal might be transmitted through a buried wire from Carlton House to the Pavilion at Brighton in one minute; and he adds—"Were the time occupied five minutes, I should count this objection rather serious, but "not insurmountable." As a matter of fact telegraphic signals can be transmitted over a continuous wire in an almost imperceptible space of time, the time occupied in transmitting a message being regulated by the number of signals to be transmitted. But Mr. Ronalds's idea of speedy communication was rather in advance of the requirements of his age, and of the means placed at his disposal. His underground telegraph was, however, a very fair specimen of what exists in the present day. We use iron or earthenware pipes in lieu of his wooden trough; but we are not very far in advance here, for he points out in his book, by way of anticipating possible objections to his plan, that cast-iron troughs might be rendered as "tight as gas-pipes," should it be found desirable to employ them. The "thick glass tubes" through which he led his conducting wire have been replaced by that useful substance gutta-percha, which had not been discovered in Mr. Ronalds's day, but which is now used most extensively as an insulating substance in all operations

connected with telegraphy. Not only in the method of constructing, but of testing and keeping in repair our underground telegraphs, have we very closely followed out Mr. Ronalds's ideas. Dealing with the subject generally, he says—" The liability of the subterranean part of the apparatus to be injured by an enemy, or by mischievously disposed persons, has been vehemently objected. If an enemy had occupation of all the roads which covered the wires, he could undoubtedly disconnect my electric signs without difficulty; but would those now in use (the old semaphore, presumably) escape? And this case relates only to invasions and civil wars; therefore, let us have 'smokers' enough to prevent invasions, and kings that love their subjects enough to prevent civil wars. To protect the apparatus from mischievously disposed persons, let the tubes be buried 6 feet below the surface of the middle of high roads, and let each tube take a different route to arrive at the same place." Of course, the danger which Mr. Ronald here suggests has never menaced our lines of underground telegraph. But his notion of alternative routes is precisely what is done in the Postal system as regards overhead wires; the object being, of course, to divide the risk of having the whole communications with certain places devastated by storms like those which have recently played such havoc with the wires. "Could any number of rogues, then," continues Mr. Ronalds in his characteristic style, "open trenches 6 feet deep, in two or more different public high roads or streets, and get through two or more strong cast-iron troughs, in a less space of time than 40 minutes? For we shall presently see that they would be detected before the expiration of that time. If they could, render their difficulties greater by cutting the trench deeper; and should they still succeed in breaking the communication by these means, hang them if you can catch them, d—n them if you cannot, and mend it immediately in both cases." Mr. Ronalds must have rejoiced at having lived to see a time when cutting the telegraph wires, or otherwise wilfully interrupting the communication, was punishable as a felony; but he proposed to rely on other means than Lynch Law in maintaining his system, and here, again, the telegraph engineers of the present day have followed out his ideas almost to the letter. He proposed to keep his wire constantly charged with electricity,—in other words, to work it on the "permanent current principle;" then to have certain "proving stations," as he calls them, at frequent intervals along the line; and a staff of persons who would constantly watch the "provers," and set out the moment that any indication was given that the line was interrupted. Suitable situations for such proving stations he conceived to be "post-offices in towns and villages, turnpike-gates, and the like." Then he continues:—"We will imagine twenty proving stations established between London and Brighton, or any distance of 50 miles, only four persons employed (but not exclusively) to keep watch over them, and each watchman to have the charge of five provers. It is evident that (were he to dwell at the centre one of the five) in order to examine the two on each side of it, he would have to ride only $4\frac{8}{10}$ miles, which journey he could easily perform in something less than forty minutes, and he would discover that the defect rested somewhere between two of the provers, a distance of $2\frac{4}{10}$ miles. Any sorry little twopenny post cove might take a canter on his Rozinantuolo, and, on his arrival at a prover, perform the operation on it in less time than I have employed to describe the manner of its performance." Now, what are these innumerable "flushboxes" which are to be found everywhere in the streets of London, and other large cities, but "provers" of our underground telegraphic system? Most people are familiar with the snake-like coils of apparently dirty rope, but really telegraph wires, which are every now and then laid bare in those curious apertures in the pavement, and the little clock-face, with only a single handle, which is the invariable companion of the workman engaged in the hole. He is simply "proving" a wire which has been found faulty, or, it may be, trying to detect one which has shown too great a liking for its next-door neighbour. Then, again, as regards over-head wires, what are the "linemen" stationed at certain intervals along the route of a trunk line but the "provers" of the section which it is their duty to traverse from time to time, working on either side of their station, precisely as Mr. Ronalds would have worked his "sorry little twopenny post cove?" But besides this, there are certain post-offices along the line which are called "testing stations;" and here every morning the wires are disconnected, with the view of testing their goodness, or the reverse. When a "fault" occurs, it is thus easy to "localise" it between two stations; and hence the rapidity with which communication is now restored after a breakdown, as compared with the time long after Mr. Ronalds's treatise was composed.

Mr. Ronalds was, perhaps, as little vain of his achievements in the telegraphic field as the most modest inventor could have been; but many of his prophecies have been fulfilled to the letter. He suffered much at the hands of those who should have been his best friends, as also did other inventors in the same field,—notably, Mr. Alexander, a Scottish electrician, who could not hear the name of "telegraph" without a shudder. Speaking of his treatment by the Government of that day, Mr. Ronalds says:—"Lord Melville was obliging enough, in reply to my application to him, to request Mr. Hay to see me on the subject of my discovery; but before the nature of it had been yet known, except to the late Lord Henniker, Dr. Rees, Mr. Brande, and a few friends, I received an intimation from Mr. Barrow to the effect that telegraphs of any kind were then wholly unnecessary, and that no other than the one then in use (the old semaphore) would be adopted. I felt very little disappointment, and not a shadow of resentment, on the occasion, because every one knows that telegraphs have long been great bores at the Admiralty. Should they again become necessary, however, perhaps electricity and electricians may be indulged by his Lordship and Mr. Barrow with an opportunity of proving what they are capable of in this way. I claim no indulgence for mere chimeras and chimera framers, and I hope to escape the fate of being ranked in that unenviable class."

Unquestionably, Mr. Ronalds was no "chimera framer." He early devoted himself to the study of a system of communication which has distanced all competitors, whether for Imperial, commercial, or social purposes; he lived to be Sir Francis Ronalds, and to bequeath a valuable collection of electrical works to those who have succeeded him in his labours; and we have seen by the perusal of his simple, yet clear and forcible treatise, describing "An Electric Telegraph," how much and yet how little we have learnt during "Fifty Years' Progress."—*Times.*

Proceedings of Societies.

SOCIETY OF TELEGRAPH ENGINEERS.

THE first meeting of the Session took place on the 13th inst., at the Institution of Civil Engineers, when the new President, Mr. LATIMER CLARK, read an exceedingly interesting Address "On the Early History and Growth of Telegraphy," which will be fully reported in our next number.

NOTICE TO SUBSCRIBERS.

Arrangements have been made for the publication, in these columns, of a series of biographical sketches of our English electricians, and of elementary papers on the practical construction of a line of telegraph, including the fitting up of offices, the choice and description of instruments, &c.; also for a series of similar papers on Electric Signalling on Railways. These papers will be written by well-known members of the Society of Telegraph Engineers. The papers on Testing, by Mr. H. R. Kempe, will be continued, and those on Duplex Telegraphy, by Mr. W. H. Preece, will be completed.

As it is our desire to make this Journal as useful as possible to the large body of telegraphists scattered over the country, we shall feel grateful for any suggestions for improvement or for hints on shortcomings. We propose establishing an exchange column, by which apparatus, books, periodicals, and other things, can be exchanged among our Subscribers, on the same plan as that which has proved so successful in other cases.

Notes.

Sir Francis Ronalds, "our eminent Fellow," says the President of the Royal Society, bequeathed £500 to that Society, but by payment of legacy duty it has been reduced to £450. His bequest was made in recognition of the advantages he had derived, when Honorary Director of the Observatory at Kew, from the sums granted to him out of the fund to aid him in the construction of his photographic apparatus for the registration of terrestrial magnetism, atmospheric electricity, and other meteorological phenomena. An exceedingly interesting account of his telegraphic projects appeared in *The Times*, which we reprint. It is worthy of record that he anticipated the observations of Siemens and Latimer Clark, and the explanation of Faraday of the Leyden jar action of underground wires. His magnificent library will, it is hoped, become the property of the Society of Telegraph Engineers.

The Institution of Civil Engineers (says that admirable periodical *Nature*) seems to be one of the most prosperous of our Scientific Societies. On its books on November 30th, 1874, were 2130 members; its income for the past year was upwards of £10,000, and its investments amount to nearly £33,000.

Snapper Sounders are now sold in the streets of New York by the street pedlars.

The following statistics—given by Mr. F. L. Pope, in *The Telegrapher*—will interest many of our readers:—

The rate of speed at which wires are actually worked is a matter of endless dispute when discussing this subject (automatic working). I give below the result of six consecutive days' actual work, taken from the records of the New York Western Union Office in 1868:—

Morse Circuits (Sounder).

Wires.	No. of Messages.	No. of Words.
No. 1, to Chicago	2,088	64,728
,, 3, ,, Buffalo	1,267	39,654
,, 7, ,, Boston	508	55,948
,, 4, ,, Baltimore ...	839	40,534
,, 11, ,, Washington ...	1,051	33,682
Total for 6 days ...	5,753	234,546

Type Printing Circuits.

No. 5, to Albany	1,308	41,108
,, 1, ,, Boston	1,948	79,638
,, 10, ,, Do.	1,719	61,979
,, 1, ,, Washington ...	1,866	76,342
,, 7, ,, Philadelphia ...	1,639	52,509
,, 8, ,, Do.	1,754	55,174
Total for 6 days ...	10,234	266,750

If we suppose each wire worked to its full capacity from 9 A.M. to 5 P.M., it would give a total of 240 hours per week for the Morse circuits, and 288 for the printing circuits, and the average result would be as follows:—

Morse, average per hour ... 977 words.
Printing, ,, ,, ... 1273 ,,

The circuits included in the above statement were at that time the busiest ones in the New York office.

During the year 1872 several instances of first class work on regularly numbered messages were timed, of which I take a few of the best:—

Morse Circuits.

330 messages in 6 hours 30 mins., 50·7 per hour.
136 ,, ,, 2 hours, 68 per hour.

Printing Circuits.

606 messages in 7 hours, 86·5 per hour.
700 ,, ,, 8 hours 45 mins., 80 per hour.

Some of the best work in this country has been done in transmitting the President's annual message from Washington to New York. The time recorded is as follows:—

Year.	No. Words.	No. Wires.	Time.	Average per Hour.
1872	11,339	12	45 mins.	1260
1873	10,635	8	59 ,,	1368

If we therefore put the best Morse transmission at 1368 words per hour, and divide it by the greatest number of messages per hour given above, which is 68, it gives us an average of 20·1 words per message, which is probably very near the truth. This would give us as the present attainable speed, in actual work, on a circuit of 20 miles, say—

Morse ... ... 1368 words per hour.
Printing ... ... 1738 ,, ,,

Quadruplex telegraphy has been successfully introduced in America by Messrs. Prescott and Edison, and a large supply of apparatus is being manufactured by the Western Union Telegraph Company.

THE TELEGRAPHS OF THE PRINCIPAL COUNTRIES OF THE WORLD.

Countries.	Length of Lines. Miles.	Length of Wires. Miles.	No. Offices.
Argentine Republic...	4,146	8,059	60
Australia	11,878	18,466	326
Austria	11,995	31,510	1,657
Bavaria	4,256	13,875	755
Belgium	2,926	12,561	547
Brazil	2,067	2,211	64
British India	15,568	31,040	770
British Indo-European	3,378	3,114	10
Canada	11,399	18,989	1,143
Chili	2,090	3,143	52
Dutch East Indies ...	2,843	3,458	51
Denmark	1,577	4,364	177
France	30,779	79,963	2,244
German Empire ...	18,999	64,753	3,325
Great Britain	23,878	99,918	5,474
Holland	2,032	7,278	315
Hungary	8,319	28,290	837
Italy	12,087	41,543	1,318
Mexico	2,955	3,338	50
Norway	4,012	6,247	148
Portugal	1,929	3,550	120
Roumania...	2,239	3,629	70
Russia	34,914	68,858	1,333
Spain...	7,287	16,572	215
Sweden	4,371	11,196	320
Switzerland	3,623	8,784	800
Turkey	16,362	28,273	393
United States	85,585	195,135	7,350
Wurtemburg	1,378	3,000	224
	335,872	821,417	30,148

—*Journal Telegraphique.*

Notices of Books.

A Treatise on Magnetism, General and Terrestrial. By H. LLOYD, D.D., D.C.L., Provost of Trinity College, Dublin, &c. London: Longmans, Green, and Co. 1874.

DR. LLOYD'S famous treatise on the wave theory of light marked an epoch in our knowledge of that subject; and now, in his mature age, he has published a work which—though not likely to rank with his former treatise—will unquestionably be of great value to every physicist. The splendid instrumental means for observing the elements of terrestrial magnetism, which Dr. Lloyd devised, and which have been under his su-superintendence at Trinity College since 1838, have furnished him with magnetic observations probably unequalled for extent and accuracy. Many of the results he has thus obtained have been reported from time to time at the meetings of the British Association, and in this work they are given in an accessible form. Moreover, the theoretical principles involved in the instruments employed in magnetical observatories, as well as the construction and adjustment of the instruments themselves, are fully and admirably detailed in this treatise, which is likely, therefore, to become a standard work for reference on these subjects.

The fact that the present volume—as the author tells us in his preface—was projected, and partly completed, many years ago, probably accounts for the omission of the many valuable contributions to the science of magnetism which have been made of late years by English and Continental physicists. We certainly expected to find some reference to Prof. Clerk Maxwell's famous treatise on "Electricity and Magnetism," but, so far as we remember, it is we believe unnoticed; nor have we met with any recognition of Sir W. Thomson's, nor Prof. Maxwell's, nor Prof. Wertheim's researches. On the other hand, the important laws deduced by earlier philosophers are classified at some length. A full account is given of Coulomb's investigations, and the conclusions he obtained are discussed with care: this portion of the volume will be extremely useful to students. The less frequently quoted experiments of Barlow are here noted, from which the effect of heat was shown to produce two effects on the magnetism of a steel magnet. When a magnet is exposed to a temperature not exceeding boiling water it loses a portion of its magnetism, and, as is well known, it recovers a *part* of this on cooling. So that a moderate heat acts in two directions on a magnet,—destroying one portion of the free magnetism, and rendering latent another portion. Upon this Dr. Lloyd makes the following suggestive remark:—"This two-fold operation of heat, although fully recognised as a fact, has not been sufficiently considered in reference to the cause. There seems reason to believe that the two effects, so dissimilar in their conditions, are in fact referrible to distinct causes; and that while the permanent loss of magnetism is a *dynamical effect* due to the molecular movement in which heat is known to consist, the recoverable portion is probably to be ascribed to the *dilatation* of the body, and to the diminution of the reciprocal action of the magnetic elements consequent upon their increased distance."

Further on we meet with the following striking passage upon the theoretical bearing of the results of heating dia-magnetic bodies, and of the general phenomena of magne-crystallic action. The facts of magnetic induction compel us to admit that the separation of the magnetic fluids is limited to the molecules of a body; hence "we must suppose that the intervals of these molecules are either absolutely void or filled with some substance of a different nature which is impervious to the magnetic fluids. The magnitude of these intervals is of the same order as that of the molecules themselves; but the proportion of these magnitudes is probably different in different bodies. The ratio of the sum of the volumes of the magnetic molecules to the entire volume may be termed the magnetic density of the body. Its magnitude will vary, even in the same body, with temperature, and other physical conditions; and it is upon that that the capacity of the body for magnetism appears to depend. This view is confirmed in a remarkable manner by the other properties of the magnetic metals. Iron and nickel are, as we know, the most powerfully magnetic of all known substances. But when we compare the specific gravities of the metals with their atomic weights, we find that these very metals are those in which the space occupied by the molecules bears the greatest ratio to the entire volume,—*i.e.*, in which the magnetic density is greatest. We are therefore justified in concluding that the capacity for magnetism in these, and therefore probably in other metals, is due to the proximity of the molecules."

Terrestrial magnetism and the description of the instruments in the Dublin Observatory occupy—as we have already remarked—a large and important portion of this treatise. Our limited space forbids us to dwell

on this part of the work. In the Appendix are printed some most useful memoirs; especially we note that on the effect of humidity of the air, on the position of a magnet suspended by silken fibres, and the reprint of Dr. Lloyd's paper on the direct magnetic action of a distant luminary on the diurnal variations of the magnetic force at the earth's surface. In this paper (published originally in the *Philosophical Magazine* many years ago) it is shown that the phenomena of the diurnal variation are *not* caused by any *direct magnetic* action of the sun and moon. And, as Mr. G. J. Stoney has subsequently proved, the *magnitude*—as well as the nature—of the diurnal variation is equally inconsistent with any explanation of the direct action of these bodies.

We feel ourselves but as young and raw students of science when in the presence of Dr. Lloyd's wide experience and powerful grasp of his subject; hence, rather than attempt any criticism of this work, we prefer to listen to the instruction Dr. Lloyd gives us: our readers, we feel sure, will also be glad to have had their attention directed to this able work: for, notwithstanding Dr. Lloyd's advanced age, this treatise is a pleasing evidence that still his eye is not dim to observe, nor does his natural force seem much abated.

[*Written by a Telegraph Clerk on the back of a Message Form.*]

LOST OPPORTUNITIES.

In times that are over, full many a lover
Was won by the power of electrical fire;
There was working, then sporting—conversing, then courting,
And letters by post followed wooing by wire.

The couples then mated are closer related,
And many a one who was helped in his work,
By patience, attention, and care beyond mention,
Has found a kind helpmeet in his fellow clerk.

But, now, things are changing, stern rules are estranging
The workers, and striving all likings to baulk;
Lest people should choose them, and Government lose them,
"*The Staff, on the wires, are forbidden to talk!*"

Odd moments of leisure, once given to pleasure,
Are spent in dull idleness now thro' the day;
And kept thus asunder, can anyone wonder
If patience, at times quite exhausted, gives way?

It is so annoying, one might be enjoying
The cosiest chat with the nicest of friends;
But there's always the fear now that somebody's near now,
And "taking us down from the slip" at both ends.

Correspondence.

CLOSED CIRCUITS.

To the Editor of the Telegraphic Journal.

Sir,—I have often been struck with the fact that in America and in our Colonies the system of closed circuits is almost exclusively used. Can any of your readers inform me why that system is not used in England, or why the open system is not used in America?—I am, &c.,

Telegraphist.

[*Note.*—As a rule we object to letters appearing in our columns under pseudonyms, because a license is frequently assumed under a *nom de plume* which would not be used if the communication appeared under the writer's proper signature. In the discussion of such purely technical questions as the above we shall withdraw that objection; but every communication must be accompanied by the writer's name and address—not for publication, but as a guarantee of good faith. —*Ed.* Tel. Journ.]

ELECTRICAL PROBLEM.

To the Editor of the Telegraphic Journal.

Sir,—I submit the following problem to your readers for solution:—

"Transmit alternately positive and negative currents within a closed circuit from a battery all the poles of which are connected in the ordinary manner, using an ordinary Morse key, to which no extra point or appliances whatever is to be added. No device other than the battery, key, and connecting wires is to be used." I enclose two diagrams, both solving the problem in a different manner.—I am, &c.,

Thos. A. Edison.

Newark, N. J., November 25, 1874.

Electrical Science in English and Foreign Journals.

Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences, Vol. lxxix., No. 23. December 7, 1874.

On the Actions produced by the Simultaneous Meeting of Battery, and of Electro-capillary Currents.—By M. Becquerel.—M. Becquerel enquiring if it were possible to increase or diminish the intensity of electro-capillary actions by making use of the current of a battery of several elements, used two apparatus. The first was a cracked tube containing a metallic solution, and immersed into an eprouvette with an alkaline solution; the second was a pervious partition apparatus—a tube closed at bottom by a piece of parchment paper and containing a metallic solution. This latter was plunged into an eprouvette containing an alkaline solution. The electro-capillary action was increased by means of two plates of platinum in connection with a battery; the positive plate being immersed into the metallic solution and the negative plate into the alkaline. The resultant electro-chemical actions were very different according to the nature of the solutions experimented upon. Copper and lead were reduced to the metallic state; silver, bismuth, and iron were hydrated with the alkaline; whilst gold and zinc gave no deposit. Wherefore these differences? They result undoubtedly from two existing currents, the lateral and central. The former tends to conduct metals in the metallic state to the negative surface of the pervious tissue, viz., the parchment paper, and at the same time the alkaline and the oxygen are transported to the positive plate. The elements meet on the negative surface, and the effects produced depend upon the affinities of these different substances; thus, if sulphur has a great affinity for the metal a sulphate will be produced. This takes place, as before stated, with silver, bismuth, and iron; but, if the reductive property of the current gets the better of the affinity of the metal for sulphur, a metallic reduction ensues, such as takes place with copper and lead.

On Magnetism.—J. M. Gaugain.—(Paragraphs 82 to 84). The permanent magnetism of a section m.m. may be considered as formed of two parts, the one which is maintained by the coercive action of the section, and the other which results from the actual reactions of all the other sections of the bar.

Nos. 24 and 25. December 14 and 21, 1874.

These numbers contain nothing of interest to our readers.

Journal Telegraphique. Vol. ii., Nos. 33 and 34.

Continuation of Paul Dupré's paper on *Telegraphic Legislation.*

The Jaite Telegraph.—By W. Gurlt, of Berlin.

Sockets for Metallic Posts.—A letter from J. M. Collette, of the Dutch telegraphs. He says, referring to a former paper by M. J. de la Taille on this subject (recommending the fitting of iron posts into concrete blocks), that the description of the line therein described agrees with one erected in Holland during 1873, excepting that the fixing of the posts into concrete blocks was not effected in precisely the same manner. The difference appears to have consisted in first making the concrete blocks in a mould, and then, at the place of erection, fastening the posts into them with cement.

Nature. Vol. xi., No. 268. December 17, 1874.

M. Becquerel—giving his opinion respecting the proposed founding of an Observatory for Physical Astronomy in the vicinity of Paris—states that he divides the formation of our planet in three calorific epochs:—(1.) When the elements were in a gaseous condition, with all the constituents consequently in a dissociated state. (2.) That in which the temperature being sufficiently lowered, affinities commenced to exercise their action. During all the chemical reactions which occurred there would be produced an enormous disengagement of electricity arising from the energy of these reactions, and, as a consequence, a re-composition of the two electricities would rend with vivid gleams the atmosphere already formed. (3.) The formation of water by further decrease of temperature. The same number of this periodical informs us that "A series of experiments has lately been made by the Prussian Government with reference to the use of electricity for the head-light of locomotives, and that a battery of 48 elements makes everything distinct on the railway track to a distance of over 1300 feet."

Bulletino Telegrafico. Anno x. September, 1874.

In addition to official regulations and personal intelligence, this number contains an article on the administration of the telegraphic system in England, taken from *Fraser's Magazine.* The telephone is an instrument devised by Mr. Elisha Gray, of Chicago, for transmitting sounds by means of an uninterrupted electric current. His experiments have already resulted in the transmission of a most intelligible sound to the distance of 2400 miles. The apparatus consists of three parts,—the transmitting instrument, the conducting wire, and the apparatus for receiving the sound. In one of these experiments Mr. Gray sounded, on a small melodium, certain national hymns, which were repeated note for note on a violin connected with the above-mentioned apparatus, 2400 miles away. The transmitting apparatus consists in a key-board with a quantity of electro-magnets corresponding to the number of the keys, to which are attached vibrating tongues or reeds, according to the tones of the musical scale. Each of these tongues may be put in motion separately, by the pressure of the corresponding key. The various tones are obtained by touching the keys exactly as with an ordinary pianoforte or melodium. To the transmitting instrument is attached a conducting wire, of which the termination is connected to the receiving apparatus. The length of the wire connecting the transmitting and the receiving apparatus may be from one to ten thousand miles, provided the insulation be sufficiently perfect to prevent the dissipation of the electric current.

October, 1874.

The non-official portion of this number is taken up with a continuation of the description of the telegraphic system of England, commenced in the September number.

City and Commercial Notes.

THE Eastern Telegraph Company's traffic receipts for the month of December, 1874, were £31,725, against £35,238 in the corresponding period of 1873.

The traffic receipts of the Eastern Extension, Australasia, and China Telegraph Company (Limited) for the month of December, 1874, were £18,172, against £20,400 for the corresponding period of 1873.

The Great Northern Telegraph Company's traffic receipts for the month of December, 1874, were 294,338 francs; 1873, 287,356 francs. Total traffic receipts 1st January to 31st December, 1874, 4,427,890 francs; 1873, 3,352,542 francs.

The traffic receipts of the Direct Spanish Telegraph Company (Limited) for December, 1874, were £1271 15s. 4d., against £1224 10s. in November.

The Directors of the German Union Telegraph Company have decided to pay an interim dividend of 11s. 9d. per £15 bond.

The Western and Brazilian Telegraph Company (Limited) have announced an interim dividend of 5s. per share for the past quarter.

The Eastern Extension, Australasia, and China Telegraph Company (Limited) gave notice that the transfer books would be closed from the 8th to the 14th January, both days inclusive, for the purpose of payment of an interim dividend of 3s. per share.

The Eastern Telegraph Company announced that the register of transfers would be closed from the 7th to the 14th January, both days inclusive, preparatory to the payment of the interim dividend of 2s. 6d. per share already announced.

The offices of the West India and Panama Telegraph Company (Limited) have been removed from Old Broad Street to St. Stephen's Chambers, Telegraph Street, Moorgate Street.

The Black Sea Telegraph Company state that telegraphic communication has now been established between Constantinople and Odessa, and the Odessa offices are connected by wires with the Russian land lines.

TELEGRAPH SHARE LIST.

Amount per Share.	NAME OF COMPANY.	Amount paid up.	Closing Quotations.
£		£	Jan. 14.
Stock	Anglo-American (Limited)	100	74¾—75¼
10	Brazilian Submarine..	All	6⅞—7⅛
10	Cuba	All	7—7½
10	Direct Spanish	9	6—8
20	Direct United States Cable	All	10¼—10¾
10	Eastern (Limited)	All	7¾—8
..	Do., New	..	103—105
10	Eastern Extn. Australia and China	All	7¾—8
10	Globe Telegraph and Trust	All	6½—6¾
10	Do., 6 per cent Pref...	All	10—10¼
10	Great Northern	All	11—11½
25	Indo-European	All	16½—17
10	Mediterranean Extension (Limited)	All	3½—4
10	Do., 8 per cent Pref...	All	10½—11
10	Panama and South Pacific	2½	..—..dis
8	Reuter's..	All	11½—12
Stock	Submarine	100	206—211
1	Do., Scrip	All	2—2¼
10	West India and Panama	All	4—4½
10	Do., 10 per cent Pref.	All	10—10½
20	Western and Brazilian (Limited) ..	All	14½—15
1000 dls.	West Un. U.S. 7 per cent 1st M.B.	All	104—106
10	Hooper's Telegraph Works	All	13¾—14
50	India-Rubber and Gutta Percha ..	All	22—24
Cert.	Submarine Cables Trust	100	105—108
12	Telegraph Construction	All	29—29½
100	Ditto Ditto 7 per cent Bonds	All	100—103

To Correspondents.

A STUDENT desires to know the proper pronunciation of the word "electrolysis." He has heard it pronounced "electroly'sis" and "electrol'ysis" by very able electricians. In reply, we have to say that our best lecturers pronounce it in the latter way.

THE TELEGRAPHIC JOURNAL.

Vol. III.—No. 48.

EXPERIMENT.

The chief function of a Journal like this is to supply an admitted want. All our student readers cannot attend lectures, join classes, or frequent libraries. We endeavour to meet this want by reporting lectures and supplying papers for study and thought. But we cannot make, though we can describe, experiments. No progress in any science can be made by the mere cursory reading of a lecture, and therefore our efforts to train electricians must fail unless the student repeat with care and exactness the experiments described. In our large cities lectures are so frequent, and physical literature is so abundant, that many satisfy themselves with seeing an experiment performed, or grasping its result from illustration and description, rather than by repeating it for themselves. It is not too much to say that an experiment is never properly comprehended until it is carefully performed, and it is the only effectual way to impress physical facts on the memory. An experiment is a knock at the door of Nature, and a successful experiment is an admittance into her secret stores. Experiment opens up the mind to, and lets in a flood of light on her mysterious ways. It is with regret that we see experiment going out of fashion. Where is the fine old glass cylindrical machine, and the equally useful Leyden jar?—instruments which have made nearly every living electrician. We scarcely ever see them in our shop-windows—we never see them in the student's hands; induction coils, magneto-electric machines, trembling bells, &c., are advertised and exhibited; but where are our old friends? A roughly home-made cylinder machine, warmed by the household fire, turned by little Bob, and applied to Pussy's nose, will teach one more of Electricity than all the paraphernalia turned out by our instrument makers. A glass tumbler filled with acidulated water, and supplied with a pair of plates, will instruct the mind more in a quiet evening than all the elaborate batteries of the trade. A little compass,—perhaps a mother's charm or a father's toy,—surrounded by a few coils of silk-covered wire, will exhibit more phenomena and supply more mental food than the most carefully finished galvanometer. The elementary facts of Electricity are so simple and so easily manifested that no one can be excused from availing himself of that great test of truth to satisfy his mind of their actuality. The simpler the means the more perfect and convincing the experiment. There are no class of persons so favourably situated for experiment as telegraph operators. Their business is a constantly repeated experiment. They have always currents at their disposal; wires, magnets, switches, batteries, surround them. There is no excuse for ignorance, or for the plea of want of means. Nevertheless, it is a most regrettable fact that experiment is rarely or ever resorted to, and those who should know most about the science in reality know least. There are some brilliant exceptions. In many of our large towns—notably Brighton, Leeds, and Bristol—mutual improvement classes have been formed by the telegraph staffs, and have proved very successful. They meet to read and discuss papers on various subjects. Do they experiment? Have they undertaken to repeat the illustrations in such lectures as Dr. Gladstone's? Do they make their own apparatus? Do they attempt original research? These are the means by which progress is made, knowledge gained, and science established.

JAPAN.

THE IMPERIAL COLLEGE OF ENGINEERING, TOKEI.

We have received the Calendar 1874-5 of this remarkable College, established in Japan. It has adopted as its motto "Energy." It has been established by the enlightened Government of that country for the education and training of young natives in Science and technical knowledge, with a view to their employment in engineering services. The regulations and syllabus of studies have been approved of by the Imperial Government of that country. The Principal is Prof. Dyer, of Glasgow, and he is surrounded by an excellent and able staff, amongst whom is Mr. Ayrton, of the University College, London, who passed a course of theoretical electricity under Sir William Thomson, in Glasgow; of practical telegraphy under Mr. Preece, in Southampton; and who was for some time in the Indian Telegraph Service. He is Honorary Secretary for Japan of the Society of Telegraph Engineers.

The Syllabus of the Course of Telegraph Engineering and the training the young Japanese will have to undergo appears to be very complete. It embraces the construction and working of Telegraphs and Torpedoes.

There appear to be nearly two hundred students, who are divided into cadets of the first year, cadets of the second year, and two preparatory classes, each divided into two sections. The course of training extends over six years, the last two years of which will be spent wholly in practical work. Workshops and drawing offices have been established, and a passage through them forms an essential part of the curriculum. Admission to the College is obtained by competitive examination, for which all Japanese subjects between the ages of 15 and 20 are eligible. The course classes and accessories are based upon the best European

models, and there can be no doubt that the young Japanese idea has the advantage over the generality of his European brethren in learning how to shoot.

THE THORPE RAILWAY ACCIDENT.

SIR CHARLES ADDERLEY has addressed to the railway companies a circular letter, in which he announces the determination of the Board of Trade not to sanction the opening of single lines which may hereafter be constructed for public traffic, except upon the express condition either that they shall be worked upon a combination of the train staff with the block telegraph system, or that only one engine or train shall be allowed to be upon the line at any one time.

No one can doubt that freedom from accident is obtained not so much in that one system of single line working is superior to another, as that—whatever the system—it should be fenced about with checks and safeguards precisely expressed and carefully observed. In the accident in question there does not seem to have been any superfluity of these safeguards. Indeed the entire management and working of the fatal section would seem to have been dependent solely upon that human fallibility which, sooner or later, is known to fail. For years the working of the line had been conducted upon the same principle, and for years it had been conducted with perfect safety. However much this may have been due to light traffic, punctuality, or to other causes, perhaps none can tell; but this one fact stands boldly forth in the train of many another of its class, viz., that the human machine, without check, is not reliable.

At the same time, no one conversant with railway work would counsel reliance upou the block system alone as a form of protection any more than upon that source which has, in this case, given us such lamentable proof of its fallibility. The safety of the tremendous traffic which now fairly floods many portions of our important lines is to be secured only by ruling and regulating it under different organisations, all working independent of each other, yet harmoniously together. Thus, if a train break down in a block telegraph station, it is the first duty of the guard—although he knows that, if the block signal instructions are faithfully carried out, no other train will enter the section so long as his train is within it—to proceed some distance in the rear of his train, and there to protect it from any following train by such hand-signals as he has. On single lines the crossing points of trains are laid down in the time-tables, and so long as trains keep time the services of the Superintendent in charge of the line are not called into requisition, but on busy days—with extra trains and heavy traffic—his post is as onerous a one as may well be imagined. To him alone is entrusted the crossing of trains at other than the points laid down in the time-table. To many this may seem a mere matter of a message either way; as "A to B—Send on 3.5 train to C," and the reply "B to A—3.5 train left for C at —;" but the importance of the subject and the life at stake demand the greatest and gravest attention in forming the code of regulations by which these crossings are effected.

Probably no more perfect system exists than that in use upon the London and South-Western Railway. By its means for years the Company's single lines between Basingstoke and Exeter, the Portsmouth Direct, and the North Devon branches have been—and some portions still are, together with the Mid Hants line—successfully worked. The greater portion of these lines are now still further protected by block signals, but this in no way interferes with or alters the crossing places of trains. The Superintendent of the line, or section of line, alone is responsible for this, and crossings other than those laid down in the working time-table can only be effected under his orders.

The position of trains is notified by appointed "train signals" from certain stations: by this means the Superintendent is aware whether they are running to time, or, if not, how much they are behind, and regulates the crossings accordingly.

At each station four special pads of telegraph forms are kept solely for crossing purposes. Two of these pads are coloured *red;* the other two are coloured *green.* One of the red pads consists of forms headed "Order for Train NOT to proceed on Journey," and bears on the back of each red leaf a form headed "Special Order to Engineman and Guard NOT to proceed on Journey." The other red pad consists of similar forms, with the additional heading of "Agent's Reply," but with no form of "Special Order to Engineman and Guard" on the back. The one green pad consists of forms headed "Order for Train TO PROCEED on Journey," and bears on the back of each green leaf a form headed "Special Order to Engineman and Guard TO PROCEED on Journey." The other green pad consists of similar forms, but each is headed "Agent's Reply," and bears no special order on the back.

Now suppose two trains, proceeding in opposite directions, are required to cross at Station B instead of Station A.

Station A is the regularly appointed crossing point, and the up train is to time, whilst the down train is considerably behind. In the ordinary course of things the up train will stop at A, whilst the down train would proceed on to the same point. The first thing to be done is to make sure of stopping the down train; B is accordingly telegraphed—

> Keep 5.15 down train from W at B till 7.10 up train from X has arrived at B.

This message is then repeated back to insure correctness, and then handed to the station agent.

The agent then proceeds to put on the signals against the coming down train, and, having done so, he forwards the following reply:—

> I will keep the 5.15 down train from W at B till 7.10 up train from X has arrived at B.

The Superintendent then proceeds to bring on the up train by telegraphing Station A:—

> Send 7.10 up train from X on to B to pass 5.15 down train from W at B.

And during the time this is being repeated the station agent is writing the reply:—

> I will send 7.10 up train from X on to B to pass down train 5.15 from X at B.

The order to stop and *keep* the down train at B has been written on the *red* pad with the form bearing

on the back "Special Order to Engineman and Guard NOT to proceed on Journey." Thus there are two forms, the one being a manifold copy of the other: of these, the upper form is for the agent, and is his authority for stopping and keeping the train; the lower is for the engine-driver and guard. This latter is then filled up and signed by the station agent, and on the arrival of the down train shown to the guard, and, on his having read it, given to the engineman, with instructions for both to attend to it.

The other red pad has been used for the agent's reply.

The order to send on the up train has in like manner been received on the green pad at A; and the reply having been sent, the agent proceeds to fill up and sign in ink the form headed "Special Order to Engineman and Guard TO PROCEED on Journey," and, having caused such order (with the telegram at the back) to be read by the guard of the train, gives it to the engineman. The train then proceeds to B, and, having crossed the down train, the agent then apprises the Superintendent of the same, which completes the proceeding.

Although this may seem a somewhat tedious and lengthy operation, it really occupies very little time in practice. With a properly organised system, well equipped, and well looked after, it is frequently completed in three minutes. Moreover, with proper foresight on the part of the Superintendent of the line, there is seldom need of hurry: the sections between stations on single lines are seldom so short as to occupy less than eight or ten minutes in travelling, and no superintendent would think of altering a crossing place for a less saving in time than this.

Now let us see how and what protection we get under this system at these crossing points, or in other words, to prevent two trains, proceeding in opposite directions, entering the same section.

First, then, we have the regular appointed crossing places by the time-tables, known to the agent, the signalman, the guard of the train itself, and the engineman,—all concerned in observing it.

Then we have, acting independently of this, the electric block signals, controlled and worked under separate and special instructions, which direct that —before any train is allowed to proceed into any section—the signals at the station in advance shall be placed at "danger," and only when this has been done and acknowledged shall the train be allowed to proceed.

Then, in case the crossing place is altered, we have, first, the train proceeding *to* the regular crossing station stopped, and only when such is known to be done is the other train moved forward. Not only is the agent made responsible in these transactions, but the signalman, the guards, and the engine-drivers,—the two latter having absolute, positive, and written instructions as to their movements. Not only is this so, but the very colour of the form on which the order is written is such as to denote its purport—*red* to stop, *green* to proceed.

Next to the "train staff" system, it seems scarcely possible to conceive a more perfect arrangement than this. The staff system has no doubt its drawbacks, and many ludicrous stories are told of it as to how trains have been kept waiting until the "staff" has been brought on by mounted messengers, and other means. So long as all goes well and regularly, it is an excellent protection; indeed under no circumstances, where worked upon the recognised principles, can an accident from two trains meeting occur.

But whether our single lines are in future worked upon the existing systems, by speaking telegraphs only, by speaking telegraphs combined with a regular system of block signals, or by the combined system of staff and block recommended by the Board of Trade, constant and critical supervision must be the rule. No matter what the system, however perfect, however plain and simple, however well understood, by strict control and by constant supervision alone will its efficiency be maintained. Where crossings are carried out by telegraph the detailed duties should be discharged by those only for whom they are appointed. Care should be taken to see that this is done. The telegraph forms should be regularly examined in order to see that they are so dealt with, and not one single point neglected.

The great protection to the travelling public, and to the railway director and shareholder no less than the public, will yet rest with the block system. Let lines be worked upon the staff system or by the message system, errors will arise and accidents follow. It is the old story of all the eggs in one basket. One little error without check, and the deed is past recall. With the block system we have that check; for although not impossible, it is scarcely probable, that two systems working so independent of one another should agree to commit so serious and consentaneous a blunder. We cannot but believe railway managers are every year becoming more and more alive to the advantages of the block system; and now that railway companies are the maintainers of their own telegraphs we look forward, at no distant date, to see the whole of our railway systems provided with this most necessary adjunct.

THE VOLTAIC BATTERY.

A COURSE OF SIX LECTURES,

By DR. JOHN HALL GLADSTONE, F.R.S.,

Fullerian Professor of Chemistry, Royal Institution.

DELIVERED AT THE ROYAL INSTITUTION OF GREAT BRITAIN.—CHRISTMAS, 1874-5.

LECTURE II.—THE REPLACEMENT OF METALS.

IN my previous lecture I spoke of metals, of acids, and of salts. Now, as I want above everything to be clear, I should just like to spend a minute or two in explaining the meaning of those terms. I shall use them over and over again to-day, so they ought to be clearly defined.

As to metals, I do not think any boy or girl in this room will have much difficulty in understanding what they are, although perhaps you could not define them as a chemist would. We all know the metals copper and zinc, silver and gold, iron and tin, and many others.

As to acids, there are a great number of acids known to chemists. They are called by that name because they generally have a sour taste, but that is not a necessary property of them. They all consist of two parts, and one of those parts in a proper acid is hydrogen; they are formed, in fact of hydrogen and something else.

A salt also consists of two parts. You are acquainted with common salt, and with some others, such as smelling salts and Epsom salts; but we chemists know a great number. There are several upon the table. Here is one, sulphate of copper; here is another, nitrate of silver. These are all substances that resemble one another in this respect—that they consist of two parts, and one part is a metal. The other part I do not exactly know what to call it before you to-day. I might name it an acid, but that would not be very accurate. I might call it an electro-negative element—that would suit my present course of lectures, no doubt; but as yet it would not be intelligible. Well, then, we must remember that every salt consists of two parts—a metal and something else; and we must remember, also, that every acid consists of hydrogen and some other thing. For instance, sulphate of zinc consists of the metal zinc along with the sulphuric element. Sulphuric acid consists of hydrogen and this sulphuric element: the hydrogen plays the part of a metal. I hardly like to say that hydrogen is a metal; for though chemists could give twenty good reasons why hydrogen should be considered such, and none why it should not be, still it is so unlike a metal that you would hardly forgive me if I called that light gas, which floated our balloon to the upper regions of this room, a metal. You will please to remember, then, that when we speak of salts, or salts dissolved in water, we are speaking always of something which can be divided into a metal and some other substance.

In the last lecture we had a large cell in front of us, as you will recollect; and in that cell you saw zinc dissolving in sulphuric acid. You will recollect that the zinc turned out the hydrogen from the sulphuric acid. You recollect, too, that the copper could not turn out the hydrogen from the acid. But we can make copper join with sulphuric acid in another way, so as to form this blue salt, which is often called blue vitriol. It exists in the form of beautiful crystals, which you can come and look at after the lecture if you like. Here are some fine, large, noble crystals of this blue salt—sulphate of copper. Now if I were to take some of this sulphate of copper, and dissolve it in water, and put a piece of zinc into it, we should find that the zinc would turn out the copper, just as the zinc turned out the hydrogen. I will dip the zinc into the solution, and then we will have a light turned upon it, and so I shall be able to show it more clearly to you. When I dip the zinc into the solution I see that there is a commotion taking place, and I have little doubt that upon taking the zinc out of the sulphate of copper we shall all see that something has happened—that, in fact, copper has been deposited upon the zinc. You know that copper looks, generally, a red metal; but I will not promise you beforehand that this will appear very red, for its colour will depend upon circumstances. Here is the metal copper which has been deposited upon the surface of the zinc. You can see it by means of the electric beam. Here is some sulphate of zinc taken from some of our batteries. We will take a little of this dissolved salt, and put the copper into it, and let it stand. Now, shall we find that the copper is capable of turning out the zinc? No. We may keep it in the solution as long as we please, and we shall find no effect whatever. There is no white zinc deposited on that red copper. If we hold it in the light we shall see that the copper looks just the same as before I put it in. There is no metal deposited, and no change.

We find, then, that the zinc can turn out the copper from sulphate of copper, but the copper cannot turn out the zinc from sulphate of zinc.

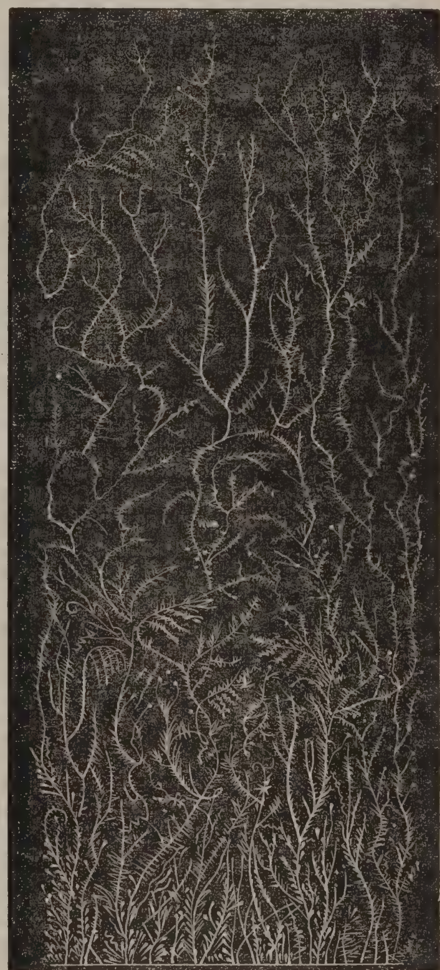
Let us go a little farther. Suppose we take some other metal. I will begin with a silver salt. These two vessels originally had some nitrate of silver in them—a salt that is sometimes called lunar caustic. Some mercury was put into these vessels. This one was prepared by Prof. Faraday,—of course several years ago,—and it is kept as a memento of him. This other specimen was prepared within the last few days, and we will make use of it because it stands up better. The mercury has turned out the silver, so that the silver is growing like crystals. Let us see how it looks in the electric light. [The vessel containing the silver crystals was placed in the track of the electric beam.] We have thus found that mercury will turn out silver, or that mercury is stronger than silver. We will, therefore, write "silver" on the black board, and put "mercury" underneath it. Mercury has a greater—what shall I say?—a greater attachment for the acid that is in the salt than silver has? We may, perhaps, say that the acid prefers the mercury to the silver. It is just as it might happen with any of you. Suppose you have two friends, but you prefer one friend to the other; then if you are with the one whom you do not like so much, and the other comes near you, you cease talking with the first, and begin talking with the second, whom you like better. So it is with the silver and the mercury. The nitric element prefers the mercury to the silver. Now is there anything that is pleasanter than the mercury? Let us see. I have here a solution of mercury. It is the chloride, and in this case I will take a strip of copper and place it in the solution. You see it comes out quite dark, I will leave it a little longer, that it may become a litttle darker. You will understand already that this copper is turning out the mercury. The mercury is being deposited on the copper, and the copper, of course, is dissolving, at the same time, in the acid. Here is the copper, you see, with the mercury upon it. Probably if I were to rub it you would see the mercury better. You know that mercury is the same as quicksilver, and that which has been deposited has a silvery appearance now I have rubbed it, although it was only grey before.

So far, then, as we have advanced, we find that the copper is more powerful than the mercury. We will write the word "copper" under it in our list. Now let us go a little farther, and see whether there is anything stronger than copper. I have got a solution of sulphate of copper, just as I had before; but I will not take, as I did in the former case, a piece of zinc, but a piece of tin. You can hardly see what is going on, because of the deep colour of the solution. But let us see whether we get any red copper upon the tin. You must understand that we do not always get metals of the colour that you would expect, for the colour depends very much upon the condition in which they are produced; thus, probably, by the aid of the microscopes which have been placed in the adjoining room, you will see that gold may be black,

or green, or lilac, as well as yellow. Now, then, we will examine the tin. I think you will see, at any rate, that there is some copper deposited upon it. I will leave it a little longer in the solution, and then we shall see the result better, and we shall probably get the true colour of copper. However, you can already see that a change has been produced, and so I will write down "tin" under copper. Now here is a solution of tin—tin in the form of chloride. You cannot see anything; the solution looks like common water. But I will place in that salt of tin a sheet of zinc, and we will see what the result will be in that case. I do not think that the action will take very long,—only you know that tin looks very much like zinc; that is the worst of it, and therefore we shall be unable to see the appearance of the tin upon the zinc very plainly, although the action will be rapid enough. Let us see. There is no doubt about a great deposit having formed upon the zinc. Here is the tin deposited, and therefore I will next write down "zinc."

Fig. 1. Silver crystallised from weak solution.
,, 2. ,, ,, ,, strong solution.
,, 3. ,, ,, ,, very strong solution.
,, 4. ,, ,,
,, 5. ,, ,, ,, nearly exhausted solution.

Now we will go farther, and see whether anything will turn out the zinc. Here I have a solution of sulphate of zinc,—that same salt which we have been dealing with recently,—and I will take the metal magnesium. It is a metal which is very easily destroyed and rusted. I will put it into the solution, and we shall find that it will begin to act in more ways than one, and make a good deal of commotion in the liquid. You observe that there are bubbles forming, and altogether you see great signs of chemical change. If we bring the magnesium out again we shall find that it has thrown down the zinc upon it, but the zinc will not be white. It is thrown down very finely divided, so that it will appear black, or nearly so. There is this grey appearance of the zinc upon magnesium,



Silver crystallised from 2½ per cent solution magnified four times.

I think, then, that I may write down "magnesium" after zinc. I might have gone farther if I had chosen, because we might take magnesium and treat it with potassium; but I cannot show you that in water very well, for potassium would catch fire under such circumstances; but the method of producing this metal, magnesium, is by decomposing its salts by means of potassium or sodium. We will therefore put down "potassium" at the end of our list.

Silver.
Mercury.
Copper.
Tin.
Zinc.
Magnesium.
Potassium.

I mean to keep this list on the black board for another lecture, in order that I may show you something more of its significance. At the present time it stands before you simply as a list of metals, each of which is stronger than the one preceding it. The weakest is at the top, the strongest is at the bottom. When I say "the weakest," I mean that the lower ones will always turn out those above them. It depends a little upon the acid that is connected with them, but at present we will not say more upon that subject. The force which operates in these cases is what is called "chemical force" or "chemical affinity." It has been known from the early days of chemistry that there was this disposition of an acid to combine with one metal in preference to another.

You can all make these experiments very easily at home. I will vary them with an experiment with a different metal. Iron will turn out copper. You can take a solution of copper, and dip your knife into it, and then you will find that the iron knife apparently turns into a copper knife, in consequence of copper being deposited on its surface. I have dipped this knife into a solution of a copper salt, and we will see whether the copper has covered the blade already. Yes, it has done so; there is not any doubt about the copper having altered the appearance of the knife, and made it look like a copper knife rather than a steel one.

When one metal is displaced by another, it usually comes down in a crystalline form. Some of those crystals you have been looking at in the microscopes outside. I will show you how to make them. If any girl or boy rejoices in a microscope, or any kind of magnifying glass, there is hardly anything that they can have for examination more beautiful than what can be produced by means of a ittle nitrate of silver and a bit of copper or brass. I will just place a drop of the silver salt in conact with a piece of copper, and I have purposely put it upon a piece of blue glass, because I think the crystals look prettier upon blue glass than upon white. You can buy this nitrate of silver yourselves, either in crystals or in sticks, and you may dissolve it either in distilled or in rain water; then you can take a little piece of copper or brass,—it does not matter which,—and pour some of the solution upon it. As soon as we put the copper into the liquid we shall see at once that something begins to form upon it. What happens is the growing of a sort of hoary beard all about the red metal. The crystals are now growing, and if I take a magnifying glass, such as some of our elders use to read with, and look at the copper in that way, I see a beautiful crystalline fringe of white metal growing around it. I will allow it to grow, and we can examine it afterwards. I will put the glass beside it, so that you may see it better; but as you cannot see that until you come down to the table after the lecture, I should like to show you upon the screen some of these crystals. We will take a solution of silver, and some copper, and show you the way in which the silver crystals grow. Of course these preparations sometimes take a little time in arranging, and we must give the crystals time to form. What we shall throw upon the screen may appear rather pretty to you; but, to my eyes, the crystals appear so very much better when we look at them with a common microscope, that they scarcely appear pretty to me when we see only their shadows. It need not be a powerful microscope to show you this effect. Any ordinary microscope will answer. [The shadow of a piece of copper upon which silver crystals were being formed was focussed upon the screen.] That black thing is the copper, and you see these crystals of silver growing upon it. I can see by the appearance that this is rather a strong solution of nitrate of silver. There appear to be little bushes growing out from the copper; you can see them growing. But we must not dwell long over any particular specimen. We will now take a weak solution of nitrate of silver. It is a very good thing, by the way, when you make experiments of this kind with your microscopes, to make solutions of different strengths, and observe the different effects which are produced. For instance, make a very weak solution containing 1 grain of nitrate of silver in 100 grains of water. You will then get the copper covered with little black bushes. It seems very strange that the difference of strength should make the crystals black instead of white. If you have the solution a little stronger you will find little fern leaves growing out, and if you have a still stronger solution—a 5 per cent or 10 per cent solution—you may have little juniper bushes growing out in various directions. You see that when we have this weak solution there is a somewhat different form from what there was before. In the case of the strong solution, the crystals were more like a fringe than they are in this case.

(To be continued.)

Notes.

The following letter, with reference to the Direct United States Cable Company, has appeared in most of the daily papers:—

Sir,—I am desired by my Board to inform you that the *Faraday* arrived in Portland Roads this morning, at 3 A.M. She will proceed to Gravesend for the purpose of refitting and taking in stores. So soon as this object is accomplished, she will at once resume operations. The Direct United States Cable is now laid from Ireland to the United States, with the exception of 260 miles. This interval is not in deep water, and the delay in completing has been caused by a succession of severe gales. The position of the end of the cable is exactly known, and the officers in charge of the Expedition state

that there will be no difficulty in completing the laying when the weather moderates.

I am, Sir, your obedient servant,

CHARLES S. CLARKE, Secretary.

Palmerston Buildings, Old Broad Street,
London, E.C., Jan. 18.

Severe gales were not the only difficulty with which the *Faraday* had to contend. Fogs—of a density unequalled by any English mist, or, to quote the words of one who was on board, "as thick as cotton-wool"—would, in an incredibly short space of time, settle in around the ship, and entirely paralyse operations. For three weeks, almost at the outset, she was enveloped in one of these: this it was which led to the propagation of the rumour as to the loss of the vessel—a rumour which emanated, we believe, from an *employé* in the joint office of the Anglo-American Co. and Western Union Co., at Placentia. Judging from all accounts the *Faraday* would appear to have behaved splendidly during the trying time that she has had to pass through, and to have falsified in no way the high expectations which were raised respecting her after she left the builder's hands. She has now gone to Newcastle to have some damages, sustained in the recent storms, made good, and she then proceeds to New York.

The new enemy to our submarine cables which has appeared on our sea coasts, and which has developed a strange taste for gutta-percha, has been found to be the *Limnoria terebrans*, a little insect about one-quarter of an inch long. The *Limnoria terebrans* is not the only enemy to gutta-percha covered wires. Rats, in several instances, have developed a strong taste for this insulating medium. In Bristol, lately, they succeeded in finding their way—owing to the subsidence of the soil—out of an old drain into the flush boxes in the streets, and devouring the gutta-percha coating of the wires, which were thus exposed. Some even ascended the pipes, helping themselves to a mouthful of gutta-percha at different points. It is probable, however, that the shocks which passed through them, on reaching the copper wire, so astonished their weak nerves that the damage they committed was not serious.

From a correspondent in New Hampshire, U.S., we have received the following account of the construction of an overground line lately erected there, which cannot fail to interest our readers:—

"The materials used are—the American patent compound wire and Brooks's insulator. The poles are some of the best that I have seen, but I cannot definitely say what class of timber is employed, as I am not yet *au fait* in the different kinds of wood which are grown here. Specimens of the compound wire I have seen in England: it is mainly composed of steel or homogeneous iron, with an envelope or coating of copper, and over this an external covering of tin. It is supposed to possess a higher conducting power than the ordinary line wires, and consequently need not be so large or heavy as they are. After the erection of the poles, with the insulators fixed to them in the ordinary way, the process of running and stretching the wire is commenced. The wire, which is prepared in coils of a mile in length, is placed on a drum (one coil at a time); this is fixed to a small wagon, and, after shackling off, away they start, uncoiling the wire as they go. The entire wiring gang consists of but five or six men,—one to attend to the wagon; two to bind in the wire to the insulators, *i.e.*, one at a pole; and two or three for stretching the wire, which is done by hand. The horse moves off; the two men, having strapped the climbing-irons on to their legs, ascend the poles, and hook the wire on to the insulator. Speaking of these climbing-irons, they seem to me to be wonderfully good things for telegraph work, and I am surprised that no attempt has ever been made to introduce them into England. They have a spike on the inner side of the instep of each foot, and by means of them a pole is scaled as easily as if a ladder were employed, whilst they dispense with all the trouble and expense of carrying it about. The wire, being hooked into the insulator, is then pulled very tight by the two or three men whose special duty this portion of the work is, and finally bound in—by the men up the poles—with pieces of the ordinary binding wire some 4 inches in length. Each of these operations occupies almost less time than it takes me to describe them; and, although it appears next to incredible, I have seen the gang of whom I speak run, stretch, and fasten off as much as 16 miles of wire in a day,—not in one solitary instance, but on several occasions. I have never seen a wire stretched tighter with the vice; in fact, I think they err out here in pulling their wires too tight; it would never do to pull the ordinary line wires like this: however, if they weather the frost, a few ohms in the resistance will doubtless be saved! The lines are worked in closed circuit."

Climbing-irons are, however, in use in England, but to a limited extent. Linemen do not like them. The compound wire alluded to in the above letter has proved itself, in New York, greatly inferior in strength to ordinary galvanised iron wire. The Police and Fire Alarm lines of that city were constructed with that wire, and the snow-storm of December 20th entirely demolished them. The wire when laid on the ground showed no trace of the copper—nothing but steel remaining, and that nearly eaten through by rust. Great efforts were made to introduce the compound wire into England, but after a few trials Mr. Culley—anticipating exactly what has happened—declined to employ it for the Postal Telegraph lines.

Mr. Bridgeman, of Norwich, some two years ago, showed that by passing a current through a plant case in which cress seed was sown, the growth around the negative pole was considerably healthier and more luxuriant than that around the positive pole.

M. Onimus, of Paris, has tried the same experiment on frogs' spawn, and states that the development of the eggs which are in connection with the negative pole is considerably accelerated over those which are in connection with the positive pole.

It is announced that the proposed Telegraph Conference at St. Petersburg will probably meet in the month of May or June. The Russian Telegraph Department will supply the President and undertake the business management. The Submarine Companies will be well represented. The principal proposal designated for discussion is the suggestion that in future the tariff should be framed not as at present, according to the number of words, but of single letters, contained in a message, as Continental Companies find the scope given to the use of compound words largely abused.

One of the most striking feats in the history of Telegraphy was realised in connection with the report of Mr. Bright's speech at Birmingham, on Monday evening last. The proceedings at the meeting in Bingley Hall commenced at 7 P.M., and continued until considerably after 10 P.M. Reporters stationed in the Hall handed successive slips of notes to the messengers of the Post-Office Telegraph Department waiting in attendance, and by them they were rapidly conveyed in cabs to the Telegraph Office. The Wheatstone automatic instrument was called on for the exertion of its utmost powers, and no less than sixteen transmitters were in operation at the same time, assisted by a number of ordinary Morse printers worked by a key. By the use of these agencies verbatim reports of the speech of the great tribune, with summaries of the observations of less weighty speakers, were simultaneously despatched to almost every town of importance in the kingdom, Birmingham being in direct communication with every great centre of population lying between Aberdeen and Plymouth, and between Belfast and London. In all 258,000 separate words, equal to 130 newspaper columns, were signalled; and as some despatches were furnished to two or more addresses in the same town, the number of words actually delivered and published equalled 580,000, or nearly 300 columns. The energy of the proprietors of one London newspaper, *The Hour*, gave special illustration to the powers possessed by the existing telegraphic organisation. Proceedings terminating at 10 P.M. in Birmingham were fully reported to the office of the journal in question, in Fleet Street, London, at 11.30 P.M., and were published—to the length of about five columns—in a special edition of the paper that prior to midnight was being lustily cried through the metropolitan thoroughfares. In Birmingham itself the local press was not enabled to issue their report of the Bingley Hall Meeting until close on 11 P.M. The proprietors of *The Hour* were so impressed by the value of the service rendered to them that they accompanied their report of the proceedings by a graceful compliment to the efficient organisation and successful energy of the Postal Telegraph Department.

The cable connecting the Orkney and Shetland Islands is broken down. Messages are dependent on sailing vessels.

Proceedings of Societies.

SOCIETY OF TELEGRAPH ENGINEERS.

INAUGURAL ADDRESS, BY MR. LATIMER CLARK, PRESIDENT. JANUARY 13, 1875.

GENTLEMEN,—On assuming the Chair as President of the Society of Telegraph Engineers, I desire to return you my thanks for the confidence you have shown and the honour you have done me in placing me in so responsible a position. Although I shall willingly devote and unite my best efforts with yours to uphold the interests and dignity of the Society, and to increase its utility, and although I shall fulfil these duties as a labour of love, I am conscious that I shall have to ask your continued forbearance and indulgence for deficiencies.

My task is, however, but a light one compared with that which devolved on my predecessors in this chair. They had to create and establish the Society, and to perfect its organisation; and, thanks to their wise and skilful guidance, and to the liberal assistance of the Institution of Civil Engineers, we are able to meet in this magnificent room this evening some 600 members strong, and to chronicle nothing but prosperity and progress.

In this respect, indeed, we have ground for sincere congratulation, for even the parent Society—the Institution of Civil Engineers, one of the most prosperous and flourishing institutions in the world—was, I believe, thirty years in existence before it possessed as many members as we now number in our single branch of the profession.

The Electric Telegraph is not the creation of any one mind, nor did it come upon the world suddenly or in a complete form; but, like the pale beams of the rising moon, its dawn may be traced back for generations, continually brightening and gaining strength as fresh additions to our knowledge rendered the problem more feasible.

Practical telegraphy is, however, a creation of the present generation. Within the memory of most of those now present it has burst into existence and spread throughout the world with a celerity and splendour characteristic of the mysterious element which it has bent to its service, so that to-day—from the distant shores of the Pacific Ocean to the eastern limits of Asia—not only every land, but almost every town and village, has been united by the electric wire, and distance and time have been so changed to our imaginations that the globe has been practically reduced in magnitude, and there can be no doubt that our conception of its dimensions is entirely different to that held by our forefathers.

It is impossible to avoid looking back and inquiring whaf has been the cause of this singular development; and, although the ground has been trodden so often, I cannot refrain from passing in hasty review some of the steps in the rise and progress of telegraphy. For, though the history of our art may receive but little

attention from the world at large, it must ever possess an interest for the members of this Society, many of whom have borne so prominent a share in its creation and development.

There was a fabulous story among the old authors that two needles touched by the same magnet, and suspended within an alphabetic circle, would move in unison at whatever distance they might be separated. The most interesting form of this story is that related by Joseph Glanvill, M.A., in his "Scepsis Scientifica," published in 1665. He says—"That men should confer at very distant removes by an extemporary intercourse is another reputed impossibility; but yet there are some hints in natural operations that give us probability that it is feasible, and may be compassed without unwarrantable correspondence with the people of the air. That a couple of needles equally touched by the same magnet being set in two dyals exactly proportioned to each other and circumscribed by the letters of the alphabet may affect this magnate hath considerable authorities to vouch for it. . . . Now, though this pretty contrivance may not yet answer the expectation of inquisitive experiment, yet it is no despicable item that by some other such way of magnetic efficiency it may hereafter with success be attempted when magical history shall be enlarged by riper inspections, and it is not unlikely but that present discoveries might be improved to the performance."

Now here we have the early dawn of the idea of an electric telegraph.

On the 1st of February, 1758, a Scotchman, Charles Marshall, of Paisley, then resident at Renfrew, published, in the *Scots Magazine*, a full and clear description of a practicable electric telegraph, and suggested the coating of his wires with an insulating material; and he may be therefore considered, in a sense, the inventor of the telegraph.

In 1800 Galvani and Volta introduced the voltaic pile, which forms so important a feature of the telegraph of to-day.

From this time many other forms of telegraph were proposed which it is unnecessary to notice, except that in 1809 Dr. Sœmmering laid before the Academy of Science at Munich a plan in which, for the first time, the galvanic battery was employed for the transmission of the current and the decomposition of water. He also expressed the hope that his system might serve to telegraph between Munich and Augsburg, and took much pains to make it known.

In 1816 our late lamented member, Sir Francis Ronalds, produced his electric telegraph, and at great expense and trouble erected a considerable length in his garden at Hammersmith. He employed frictional electricity and only one wire, and exhibited his signals by the divergence of pith balls, combined with rotating dials working synchronously,—a system afterwards brought to great perfection in the printing telegraph of Prof. Hughes. Sir Francis Ronalds will always take a high position in the history of the telegraph, —not so much on account of the excellence or originality of his invention, as on account of the confidence and ardour with which he pursued his experiments and endeavoured to bring them to the notice of his countrymen. With wonderful prevision he fully perceived its value and foretold its destiny. His "Description of an Electrical Telegraph," which was published in 1823,—the first book ever published on the subject of Electric Telegraphy,—might almost serve for a description of a telegraphic system at the present day. He proposed the establishment of telegraph offices throughout the kingdom, and pointed out the benefits which the Government would derive from their existence. He described methods of insulating the wires either on poles or underground, with all the details of tubes, joints, and testing boxes, testing stations, linemen, and inspectors, as at the present day. But the most interesting and singular point to my mind is the clearness with which he foresaw and explained the phenomenon of retardation of the electric current by induction in underground wires,—a phenomenon which has so greatly engaged the attention of electricians in the present day.

The influence of this is so great that on our Atlantic cables we do not transmit messages at a greater rate than fifteen or twenty words per minute, whereas, if the effects of induction could be removed, we might transmit three or four hundred words per minute. After showing that the discharges through his 8 miles of insulated wire were apparently instantaneous, he says—"Yet I do not contend, nor even admit, that an *instantaneous discharge* through a wire of unlimited extent would occur in all cases." And recurring to the subject further on he says—"That objection which has seemed to most of those with whom I have conversed on the subject the least obvious appears to me the most important, and therefore I begin with it, viz., the probability that the electrical induction which would take place in a wire enclosed in glass tubes of many miles in length (the wire acting like the interior coating of a battery) might amount to the retention of a charge, or at least might destroy the suddenness of the discharge, or, in other words, might arrive at such a degree as to retain the charge, with more or less force, even when the wire is brought into contact with the earth." He then proceeds to suggest methods of obviating the difficulty, or experimentally demonstrating its extent and character.

There can be no doubt that if Ronalds had worked in the days of railways and joint stock enterprise, his energy and skill would have triumphed over every difficulty, and he would have stood forth as the practical introducer of the telegraph. But he was thirty years before his age, and the world was not ready for him.

Having completed his arrangements, he modestly invited Lord Melville—on the 11th July, 1816—to witness his experiments, in order that he might demonstrate the nature and merits of his invention. The reply he eventually received was eminently characteristic of the neglect, and even contempt, with which science and scientific men were, and to some extent still are, regarded by statesmen.

"Mr. Barrow presents his compliments to Mr. Ronalds, and acquaints him, with reference to his note of the 3rd instant, that telegraphs of any kind are now wholly unnecessary, and that no other than the one now in use will be adopted.

"Colonial Office, 5 Aug., 1816."

The inventor had chosen an unfortunate time. The great war of the century was concluded; the Government officials were doubtless closing up their affairs after a weary Session, and were thinking only of salmon and grouse; telegraphs and all other new-fangled ideas were wholly unnecessary; and Mr. Ronalds was probably only one amongst a dozen of inventors who received their *coup de grace* on that unlucky August morning.

Ronalds was, however, contending against one difficulty which, as we now know, would have been almost insuperable. Although very familiar with the galvanic pile, and although Sœmmering had used it for telegraphs seven years previously, he was still working with high tension or frictional electricity.

(To be continued.)

PHYSICAL SOCIETY.

Saturday, November 21st, 1874.

Dr. J. H. Gladstone, F.R.S., President, in the chair.

At this meeting, held at the Science Schools, South Kensington, eight new members were elected.

Prof. MACLEOD made a communication "*On a Simple Apparatus for Showing Internal Resistance in Battery Cells.*" Two tubes about half a metre long, and one of which is twice the diameter of the other, are closed at their lower ends with corks. On the corks, and within the tubes, rest two discs of platinum foil, connected with binding-screws by platinum wires passing through the corks. The platinum plates are covered with small quantities of chloride of silver, and the tubes are filled with a solution of chloride of zinc. Each tube is provided with a disc of amalgamated zinc soldered to a long copper wire, which is well covered by an insulating material. The discs are cut so that they nearly fit the tubes, one being exactly double the diameter of the other, and therefore exposing four times the surface to the action of the liquid. On connecting the terminals with a galvanometer, the current will be found to increase as the distance between the zinc and platinum plates is diminished by lowering the zinc plate in the tube. In order to obtain the same deflection of the galvanometer by the narrow cell, the distance between the plates must be one-fourth of the distance between those of the larger one.

The apparatus may also be used to show that opposed cells of the same kind will not produce a current. For this purpose the platinum plates are connected together, and the two zinc plates joined to the galvanometer. No current will flow, whatever the distances between the plates.

THE TELEGRAPH ELECTRICAL SOCIETY, MELBOURNE.

THE first Ordinary General Meeting of this Society was held on Wednesday, 12th August, at 8 P.M., at the Melbourne Athenæum, Mr. D. J. MCGAURAN in the chair.

The minutes of the previous meeting having been confirmed, the Chairman called upon Mr. L. S. Daniel to read a paper he had undertaken to produce on "*The Object, the Use, and the Working of the Telegraph Electrical Society.*"

Mr. DANIEL then read as follows :—

It is with considerable diffidence that I have undertaken to be the first to address this newly-formed Society; but as, from the first, I had determined upon doing my best to assist it by every means in my power, I felt that I could not well decline coming forward, at the request of the Committee, on the present occasion.

The subject on which I propose to try and gain your attention is that of the Society itself. I think that we should thoroughly understand why we are met here to-night, and why we have formed this Society. To put the matter in its simplest form, I would say that we are met here to gain power. Knowledge is power, and our object is to increase our knowledge. The acquisition of power will increase our value, will cause attention to be drawn towards us, and will improve our position. I need scarcely say that, if our value be increased, and our position improved, we may naturally expect a tangible recognition of this improvement; but I confess that I would never have thought of putting the matter in such plain language as I find it in the *Journal of the Telegraph Engineers' Society* of London. While I was searching for material from which to form the present paper, I came across the following passage in a lecture on the advantages of scientific education, published in that journal, and addressed to the Telegraph Staff of London, by Mr. W. H. Preece, C.E., and Member of the Society of Telegraph Engineers. [Here follows a long extract.]

He adds that *pecuniary advantages must necessarily accrue* to such as avail themselves of the opportunities of acquiring this knowledge; and to put his meaning out of all doubt, he heads this division of the advantages of scientific education with the magic word *Pay!*

With such an authority as this before us, I do not think that we need now hesitate to declare openly that one of the results we hope to obtain from the successful establishment of this Society is increased pay. I almost think that this result alone would be sufficient, in many instances, to induce a large number to enrol themselves members; but Mr. Preece points out, also, that there is pleasure as well as profit in acquiring scientific education, and I may say that I anticipate that many of us may eventually experience great pleasure in the fact that our scientific studies, prosecuted in connection with this Society, will have improved our social position and standing in society. I think, then, that in saying that this Society is established for the pleasure and for the profit of its members I shall not be far wrong, and that two better reasons for establishing any Society could hardly be found.

Most of us have been intimately connected with Telegraphy for many years,—for so long, in fact, that it would be a hard matter for us to adapt ourselves to any other calling; and I think that very few of us have any idea of following, or would wish to follow, any other calling. But, while years have been passing on and changes have been made, most of us must admit that—so far as scientific knowledge of our occupation goes—we have been standing still, or almost standing still. I believe that the time will shortly come when—if we do not arouse ourselves from this lethargic state—we whall find ourselves quietly passed by, by a new generation, who will wonder at the ignorance displayed by men who, as they will say, have been all their lives concerned with Telegraphy, and yet know so little about it. This is not a pleasant state of things to contemplate, and I confess that this idea has haunted me for a considerable time, and I hail the present movement as a favourable opportunity for us to commence a new state of things, and to lift ourselves at least up to the level of our fellow-telegraphists in other countries. We are, from our geographical position, much isolated from the great telegraphic centres, but this should be no obstacle to our being at least their equals in practical and scientific knowledge, and I may say—with, I hope, a pardonable pride—that I have such faith in Victorian energy and intelligence that I do not despair of seeing this Society, by its members, become favourably known and honourably ranked among the older and and more pretentious European and American societies. But certainly I have no wish to begin "blowing" already as to what we will do. At present we have only to confess that plenty of room exists for our self-improvement.

I have said that this paper which I am now reading would be "On the Object, the Use, and the Working of this Society." To a great extent the two first terms are identical, but on closer inspection it may be seen that an inquirer might ask us "What is your object in forming this Society?" and when told what our object is, he might say, "And what is the use of it?" and then "How do you propose to work it?" I will therefore endeavour to answer our imaginary querist in the order of his questioning. What, then, is our object in bringing this Society into existence? It is, as we have already declared in general terms at our preliminary meetings, "for the promotion of the knowledge of Electricity, more especially as connected with Telegraphy." That is no doubt a good abstract answer; but I will now endeavour to give some details as to what I consider should be the object of the Society. It should help us to acquire a thorough knowledge, theoretical and practical, of the means used by the most advanced telegraphists to carry on their work, and we should endeavour to so perfect

ourselves in this knowledge that it should be just as easy for us to thoroughly understand the use and theory of, say, Wheatstone's bridge (I select this because I confess that I really know nothing whatever about it) as of a simple Morse instrument. I have no doubt that to most of us, years ago, the mastering of the theory of the Morse instrument was considered a very satisfactory intellectual feat, and I remember when I thought I had some claim to consider myself well advanced in electrical knowledge when I had thoroughly mastered the deep mysteries of a repeating switch! I need not say how many years ago this occurred, but I bring it forward as an illustration of what I think will be the case if we apply ourselves honestly to the study of other problems connected with Electric Telegraphy, which, I am sure, cannot appear more mysterious to any of us now than the repeating switch did to me years ago. In acquiring this knowledge we must be careful not to look too far ahead at first. Many a tourist has turned back from the ascent of a high mountain from losing heart at the apparently inaccessible heights as seen from the foot, where a more sensible traveller, plodding carefully on, arrives at the summit without perhaps having actually encountered any obstacles. I believe that if we do not lose heart at first, but plod carefully along, examining *more* the ground that we are *going over* than the difficulties before us, we will ultimately arrive at a very respectable height of knowledge of Electrical Science. The knowledge of Electricity as confined to Telegraphy is not, however, the sole object of this Society. Electricity in any form is so intimately connected with the present system of Telegraphy that it will be one of the ends of the Society to encourage, as far as its limited means will allow, the prosecution of researches into that inexhaustible mine of Science.

A third object of this Society will be to endeavour, as much as possible, to keep its members posted up in *electrical news*, by means of journals or other periodicals issued by kindred Societies in Europe or America. Of course, the extent to which this can be done must depend on the funds available for doing it.

If, then, I say that the direct objects of this Society are—1st, The acquiring of knowledge of the higher branches of Electric Telegraphy; 2nd, The acquiring of knowledge of Electrical Science in the abstract; and 3rd, The keeping its Members informed of the movements and changes that are taking place in the great centres of Telegraphy; and that, by acquiring this knowledge, they indirectly gain *power*, and very probably *pay*, I think that will be sufficient answer to the question of "What is the object of this Society?"

(To be continued).

Notices of Books.

Clocks and Watches, and Bells. By Sir Edmund Beckett, Bart. (late E. B. Denison). London: Lockwood and Co.

No telegraphist should be without this book. It is one of the best treatises in the English language on clockwork. Clockwork plays such an important part in most telegraphic apparatus that its construction and regulation should be as familiar in the mouth of the telegraphist as household words. Sir Edmund Beckett's little work has now reached its sixth edition, and it has been revised and considerably enlarged. We have here all that need be known about measures of time, both ancient and modern; of clocks and watches, pendulums and escapements, trains and dials, wheels and pinions, compensations and striking parts.

Strange to say, however, he does not explain how the practical unit of time—*the second*—is derived. The sidereal day, or the time between two successive passages of the same star over any given meridian, is the ultimate regulator of all clock time, and is therefore the practical standard of time. But the second, or the *unit* of time, is the $\frac{1}{24 \times 60 \times 60}$ part of the *mean solar day*, or the mean interval which elapses between successive passages of the sun across the meridian of any place,—which is the average length of all the solar days in the year.

The illustrations are excellent.

He devotes a few pages to the description of electrical clocks, and to the distribution of time by balls and guns, but he is evidently not an advocate for electricity in the working of clocks.

Electrical Science in English and Foreign Journals.

Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences.
No. 26. December 28, 1874.

The whole of this number is filled with the Academy's report, delivered by M. Faye, in which he sketched out the origin of the various prizes offered by the Society, and eulogises the scientific labours of the members. The speech is immediately followed by a list of the prizes awarded, for 1872 and 1873, for treatises in mathematics, mechanics, astronomy, phsics, chemistry, &c.

We notice that the *Prix Gegner* for 1872, worth 4000 francs, was awarded to M. Gaugain to enable him to continue his researches in electricity and magnetism. The 1873 *Prix Poncelet*, a prize for mechanics, was unanimously given to Sir W. Thomson for his excellent labours relative to mathematical physics, and particularly for his work, *Reprint of Papers on Electricity and Magnetism.*

Amongst the subjects proposed for future years there appears one on the *Application of Electricity to Therapeutics.* It will be awarded as a medical and chirurgical prize.

Annales Telegraphique.
Vol. i., Third Series. July and August, 1874.

Electric Magnitudes, and their Measure in Absolute Units.—E. E. Blavier.—This paper is an explanation of electrical terms, and contains matter to be found in text-books of electricity.

Meyer's Autographic Apparatus, Mercadier's Electro-Diapason, and some other papers on subjects which have already been treated of in our pages during the course of last year.

September and October, 1874.

Continuation of M. Blavier's paper.

Poggendorff's Annalen der Physik und Chemie.
Vol. clii., No. 8, 1874.

Certain Experimental Investigations on Electric Vibrations.—N. Schiller.—The author's conclusions are —(*a*). The method of Helmholtz furnishes an accurate means for the experimental investigation of the theoretic laws of electric vibrations, and leads to variou determinations of magnitudes in this department. (*b*.) The duration of the vibration of oscillating currents increases as the square root of the potential of the current and the total capacity of the conductor, and of the intercalated condenser. (*c*.) The conductive power of the oscillating layers of a conductor has a manifest influence upon the suppression of the electric vibrations therein. (*d*.) The determination of the duration of the vibrations of oscillating currents leads

to a comparison of the capacity of the condensers with each other, and of the potentials of the conductors. (*e.*) The same determinations give the possibility of measuring dielectric constants when the duration of the charge is very brief. From such measurements it appears that the dielectric constants become smaller, the smaller the duration of the charge. (*f.*) The determination of the suppression of oscillatory currents gives the possibility of measuring the conductivity of feeble conductors.

Measurements of Terrestrial Magnetism.—Karl Braun (conclusion).—This part of the memoir treats of the determination of intensity by means of the inclinatorium, and remarks on measurements with the magnetometer.

Magnetic Function of a Ball of Soft Iron.—Dr. Carl Fromme.—The permanent momentum of a rotatory ellipsoid of soft iron increases in the first place with the increase of the magnetic force, attains a maximum, and then declines. The magnitude of the maximum, its time of appearance, as well as the subsequent decrease of the momentum, are all inversely proportional to the constant C, which depends on the eccentricity, and becomes smaller as this increases. The ratio of the temporary momentum to the permanent decreases at first to a minimum, which coincides in point of time with the maximum of the permanent momentum, and then again increases. The magnitude of the ratio is inversely proportional to a function of the eccentricity of the ellipsoid of revolution.

Effects of Lightning on the Steeple of St. Martin's Church, Basle.—E. Hagenbach.—The following points deserve notice :—For the space of more than 3 metres two insulated wires had been laid, for protection, in a leaden pipe. For this entire extent the copper of the wires was perfectly unchanged, whilst the gutta-percha coating showed marks of fusion in several places. This may be explained by the assumption that the conductor surrounding the wires must have acted, as in the experiments of Faraday, Siemens, &c., so that for this space an equal amount of electricity was discharged in a feebler current, but of longer duration. The wire became red-hot without being destroyed, and found time to communicate its heat to the surrounding matter.

Reply to Herweg's Critique on the Essay "On the Nature of Electricity."—E. Edlund (See *Annalen*, Bd. 150, p. 623).—The remark of M. Herweg seems to have arisen from the circumstance that perhaps, in the Essay, the distinction between the speed of motion of the molecules of the ether and the speed of the propagation of this motion has not been rendered sufficiently clear. The intensity of a galvanic current depends on the first of these speeds, *i.e.*, the speed of motion, but not on the second or that of propagation. The author refers to his work—"Théorie des Phénomènes Electriques." (Stockolm: Nastedt and Söner).

Revista de Telegrafos. December, 1874.

The non-official portion of this number contains an article on the "General Postal Treaty," and on "International Telegraphic Arrangements," taken from the *Journal Telegraphique;* a letter from San Sebastian, describing the telegraphic service there; a notice of the *Annales Telegraphiques;* the conclusion of the paper on "Projections;" and a paper on Holland, having no connection with telegraphy or with any branch of physical science.

Repertorium für Experimental Physik. Band v., Heft. 1874.

Electro-Dynamic Elementary Law.—Theodor Wand.—This memoir occupies more than half the journal. The author sets out with the statement of the fact that an electric current, by augmenting its intensity, induces a current in the opposite direction in an adjacent conductor. This experimental proposition may be also thus expressed :—Electricity reacts upon its change of locality with an electro-motive force proportional to the second differential coefficient of the locality, taken in point of time. Our hypothesis extends this proposition, so that electricity reacts not only upon its change of place as the second differential coefficient of the place, but also upon its condensation as the second differential coefficient of the density. In successive sections the author gives general explanations, the law of Ampère, the principal of the conservation of force and Ampère's law, with the action between two elementary currents according to the same law; the "integral law" of F. Neumann; Weber's law; the electric current on the hypothesis of two electric fluids; general demonstration of the unstable equilibrium following from Weber's law, with the aid of the proposition that every motion may be decomposed into a rotatory (whirlpool-like) and a radiant; Weber's law gives no determined force for radiant motion; further objection to Weber's law; the electric forces for currents without points of condensation developed according to Weber's law; the differential equations deduced from Weber's law not incorrect, but incomplete; their completion; C. Neumann's new theory; definite form of the elementary law; magnetic action of any electric process soever; fresh confirmation of the author's hypothesis; constant c (§ 14) may be assumed = unity; potential function of a current and of a sphere-solenoid; determination of constants.

Simple Galvanoplastic Apparatus for Students.—Dr. F. Plettner.—The description of a very simple and cheap apparatus for the galvanoplastic process.

GRAMME'S MAGNETO-ELECTRIC COMPANY.—In the first and second volumes of this Journal will be found records of results of experiments on Gramme's Magneto-Electric Machine, by Mr. Robert Sabine, C.E., M. Gramme, M. Gaugain, the Count du Moncel, &c. Reference is also made to an exhaustive article by Mr. William Crookes, F.R.S., which appeared in the *Quarterly Journal of Science* for July, 1873. A Company is now being formed for the application of the machine to the various industrial purposes proposed by the above-named gentlemen. The capital of the Company is to be £250,000, in 25,000 Shares of £10 each. The first issue is 17,500 Shares, of which 14,000 are now offered for Subscription, the balance—3500 Shares—being taken by the Vendor. The Share Lists close for London on the 4th, and for the Country on the 5th instant.

To Correspondents.

*** Duly authenticated contributions, theoretical and practical, on every subject identified with the interests of which "THE TELEGRAPHIC JOURNAL" is the organ, will always command attention. Anonymous correspondence will be wholly disregarded. Literary communications and books for review should be addressed to the EDITOR; business communications to the PUBLISHER

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THE TELEGRAPHIC JOURNAL.

Vol. III.—No. 49.

SCIENTIFIC PROPHECY.

Prophecy is the prediction of an event—the declaration of something to come. When future events—either in the history of the world or in the life of man—have been foretold from no known data and from no law the prophecy must have been divine, for none but God can know the future of man. When such events in the history of nature and in the life of matter have been predicted from known data and from established laws, the prophecy is human and scientific. Every science in its growth passes through three stages. First, we have the stage of observation, when facts are collected and registered by many minds in many places. Next, we have the stage of generalisation, when these well-ascertained and carefully-verified facts are arranged methodically, generalised systematically, and classified logically, so as to deduce and elucidate from them the laws that regulate their rule and order. Lastly, we have the stage of prophecy, when these laws are so applied that events can be predicted to occur with unerring accuracy. Astronomy is said to be the only science which has thoroughly reached the last stage. Other sciences are in various stages of growth. Electricity in some branches has reached the third stage, but in many branches it is still in its infantine period. Astronomy predicts eclipses, transits, occultations, for any period in the future, and the "Nautical Almanack" is the most wonderful example of prescient knowledge; a sailor may go away for a five years' cruise, and yet in this book he will find every event in the motion of the planets, the movements of the tides, the rotation of the moon, the eclipses of the sun, &c., faithfully and unerringly foretold. But Astronomy has produced greater wonders than these. The planet Uranus was found to suffer from some slight disturbances in her path round the sun. Adams in England and Le Verrier in France simultaneously and independently, from the known laws of gravity, predicted the existence and position of another unknown planet. Galle, of Berlin, directed by Le Verrier, found the planet in the spot indicated, and it was called Neptune.

Newton, the grandest scientific man the world has perhaps ever seen, and the founder of the laws that led to the prophecy just narrated, in his investigations on light, predicted the fact that the diamond was formed of some combustible material—from its very high index of refraction. The combustion of diamond is now an ordinary, though expensive, lecture experiment. Light has given us one or two other scientific prophecies. Poisson, from theory, pronounced that in the case of an opaque circular disc the illumination of the centre of the shadow caused by diffraction at the edge of the disc would be precisely the same if the disc were altogether absent. Arago proved this to be true. Again, Sir William Hamilton predicted that in biaxial crystals there were four points where the refraction of the crystal upon an incident ray produced a continuous conical envelope. Dr. Lloyd took a crystal of arragonite, and, following Hamilton's directions, discovered what the mathematician had predicted.

Whewell predicted from theory that there must be a certain point in the North Sea, midway between Lowestoft and the coast of Holland, where there was no rise or fall of the water, because the crest or high-water mark of the tidal wave, and the trough or low-water mark of the same wave reached the same point at the same time, but by different routes. Captain Hewett, R.N., found that it was so.

Electricity has its prophets. Faraday, examining Sir Charles Wheatstone's beautiful experiment on the velocity of Electricity by means of a rotating mirror, said—"If the two ends of the wire in Professor Wheatstone's experiments were immediately connected with two large insulated metallic surfaces exposed to the air, so that the primary act of induction—after making the contact for discharge—might be in part removed from the internal portion of the wire at the first instant, and disposed for the moment on its surface jointly with the air and surrounding conductors, then I venture to anticipate that the middle spark would be more retarded than before. And if those two plates were the inner and outer coatings of a large jar or Leyden battery, then the retardation of the spark would be much greater." The experiment was not made for sixteen years. It was then shown as the explanation of the retardation of the current in our subterraneous and submarine wires.

Sir Francis Ronalds, with wonderful prescience, had in 1823—fifteen years before Faraday—suggested "the probability that the electrical induction which would take place in a wire enclosed in glass tubes of many miles in length (the wire acting like the interior coating of a battery) might amount to the retention of a charge, or at least might destroy the suddenness of the discharge." Faraday's prophetic vision and Ronalds's far-sighted knowledge are verified in every working cable. The accuracy with which our cable repairers are directed by our electricians to the spot where the wire is broken, the exactitude with which the working speed of a cable is predicted, the unfelt and invisible super-

vision which is exercised over the care and maintenance of our telegraphs,—even though they pass through distant countries and different climes,—are evidences that Electricity, in this particular field, is approaching the last and prophetic stage of its growth. This field is resistance, and Ohm is its prophet.

THE VOLTAIC BATTERY.

A Course of Six Lectures,

By Dr. JOHN HALL GLADSTONE, F.R.S.,
Fullerian Professor of Chemistry, Royal Institution.

Delivered at the Royal Institution of Great Britain.—Christmas, 1874-5.

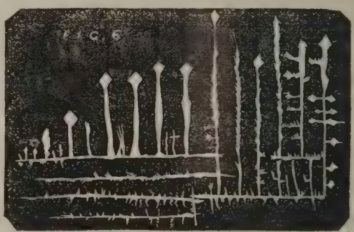
Lecture II.—The Replacement of Metals.

(Continued from page 30.)

I will now take a little bismuth. It is a metal with which you are not so familiar as with silver. We will take the chloride of bismuth, and put into it a little piece of zinc. In fact, this metal zinc—with which we became familiar the other day—will turn out almost all the common metals with which you are acquainted. A very powerful thing, indeed, is this metal zinc, and we shall use it for turning out lead, and tin, and bismuth, and some others. But, first of all, we will have bismuth. It is commonly a highly crystalline metal, and here it grows forward in great fringes. There are other metals which do the same. I spoke of silver growing in fringes, and so it does when it is very strong; but we can hardly get this bismuth to show itself in any other way. You now see the fringe of the bismuth on the screen. How different this is from the silver! You see these currents. You may see something slowly moving along—currents in the liquids, and the crystals go on growing before your eyes. Let us try another part of the metal. Here it is, with the fringe growing in all directions.

We will now take the metal thallium, which is a very rare metal, and one that has been only recently discovered. In fact, it is one of the very newest of the group of metals—the youngest born of the family, as far as our human knowledge of them is concerned. We will see how this thallium grows into crystals. I use it because it differs somewhat in appearance from the others. Some of you may know of this thallium, as it has been called, having been discovered by the peculiar green light which it emits in burning. You see how it grows in spikes, which is not the case with silver. You see this forest of pines growing up, and starting in various directions, and you see the thallium growing elsewhere into something like fern leaves. In another part it is like the fringes which we saw in the bismuth. Here come some grand pines pushing themselves forward into the liquid. We shall see these grow more rapidly with some of the other metals. We will take lead next. On the table is a large specimen of what is called the lead-tree. In order to produce this, all you have to do is to take a piece of zinc and just suspend it in a solution of acetate of lead, or any salt of lead you please. Acetate or sugar of lead is, however, that which is most easily procured. Put some zinc into the solution, and it is well to add a little acid, and lead will be deposited on the zinc. This lead-tree has been growing for some weeks, and you can see the large branches of lead on it. In fact, I should think that it had taken all the lead out of the solution, and that there is nothing but acetate of zinc remaining. We can easily set another going. You can easily procure a bottle of clear glass, fill it with the solution, and then tie a piece of zinc in it by means of string. The piece of zinc is allowed to hang thus in the solution of acetate of lead. You can do it, perhaps, a little more artistically by allowing the zinc to hang in the middle of the bottle, for it is well to have everything neatly done. I already see that the plate of zinc is covered with little spangles of bright metal. You will see what it has done by the end of the lecture, and we will let it stand that you may examine it also another day.

We will now show you some tin by means of the electric lamp and microscope. There are the crystals of tin forming on zinc. They are becoming thicker, rather than growing in length. One of them is moving about, probably with its own weight. They are becoming thick at the end. I will call your attention to one thing now before us: it was not observable in the silver, because we did not get the fern leaves formed in that case; but if you had seen the fern leaves of silver you might have noticed that the fronds of the crystals always started at an angle of 120 degrees, but here, in the

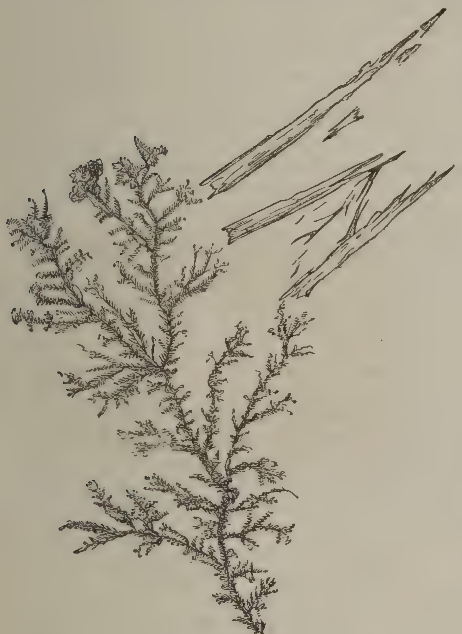


Tin crystallised.

case of tin, these cross-pieces are at right angles: the branches grow at right angles to one another, and they tend to form great cubes at the end. You see these crystals growing into cubes, so that we have a totally different geometrical character in the crystals of tin from what we had in the crystals of silver. In fact, it is one of the beauties of this subject, that if you take different metals you see a different kind of natural architecture going on. You will see that one metal will affect a certain angle, while another affects a different angle; and it is interesting to see, by means of the microscope, how beautiful that natural architecture is. When it is growing before your eyes you see minaret after minaret, and pinnacle after pinnacle, being formed, and you observe how true the form is, and how one crystal is exactly like another. Sometimes you might imagine that the growth of the crystals was the advance of different squadrons of soldiers, one behind the other, going forward towards the enemy. You see how these thick pieces are growing into large, strong crystals.

We might go on, and show you a great number of other metals in the same way. We have here a preparation of gold made before the lecture, and we will put it in and show you the effect, for gold grows rather slowly. Still it is very interesting to look at. You can see the crystals, and also the

yellow solution of gold. You see how the solution has been swept white where the crystals have been formed, and how they have cleared out the yellow from various places. Here is a long thread of crystal grown out in various ways. It has bubbles of hydrogen formed about it, but we cannot help that. Here are two patches of gold that have been growing in a crystalline form. There is another kind of gold which looks very different, and we will have a look at it, for it is more like the way in which gold most frequently appears. It is growing out in this regular sort of forward growth. We often see strange things taking place: for instance, I have often noticed that the gold salt will crystallise on the microscope slide in long, thin, needle-shaped crystals, and then the crystals of gold will grow towards the crystals of the salt; and we find that the transparent crystals of the salt are eaten up, as it were, by the gold crystals which feed upon



Gold crystallised.

them. The first time I studied this appearance particularly, I saw what I described in my notes—for want of a better term—as a caterpillar crawling along the edge of the liquid. If you watch the edges of the liquids you will often find beautiful effects. In my observation a piece of gold had floated out away from the rest—a piece of gold crystal I did not know what would happen when this caterpillar came up to it. It went on growing in the same direction, and directly it touched the loose metal it stopped, and grew no more. But the gold which had been separated was a conductor, and took up the action which had been going on in the caterpillar; so presently I began to see little sprouts of crystals from the end of it. These are the kind of things which you will see when you examine such preparations.

Now, I am afraid that I must draw upon your imagination very largely. I want you to think of what is taking place in the liquid when such a growth as those which we have seen by the microscope is happening. Of course it is very easy to imagine one metal turning out another: that must be just a chemical change, in the first instance. The zinc turns the gold out, but then directly the gold begins to grow forward in the liquid; and why is it that the fresh gold is deposited on the projecting pieces of gold, instead of being deposited on the zinc itself? And that happens, also, in all the other cases—with silver, with tin, and every other metal. There is first, then, chemical action, resulting from what we call chemical affinity or chemical force—one metal turning another out, and putting itself in its place. But directly we have that, we have what we saw in our last lecture to be necessary for voltaic action; we have two metals touching one another. We have zinc and gold, or zinc and copper, or whatever the case may be, and we have a salt between them, so that we have, as it were, a small cell, like the large one which gave us all those wonderful phenomena in the last lecture. Now, what is happening? Well, this zinc is dissolving; and I hope that even the youngest girl or boy here will remember that whenever one metal makes its appearance from a solution the other metal dissolves away at the same time. In all those cases which we saw on the screen, one metal was dissolved while the other was being deposited. You cannot, you know, put somebody else in the place which is occupied by any boy here without turning the first boy out of his place. But, while the zinc is dissolving in one place, how is it that the gold is being deposited in another? What is taking place in the liquid between? Well, it is a great thing if you can have your mind so tutored that you can form to yourselves ideas of things which you cannot see, and carry your thoughts forward; and the young can often do this better than those who are more advanced in life. But it is important so to control our imagination that we may have it firmly in hand, and so bridled that it may not run away with us, but may serve as a good horse, to carry us swiftly and safely along. Let us try to use our imagination in this way.

In the first place, we have a chemical force produced, and then a voltaic force. In this instance it seems that the chemical force is produced first; but I will say a little more about that afterwards, and perhaps we may find that the two forces are twin sisters after all. Let us see whether there is any action going on within the liquid. I will endeavour, by experiment, to show you that the solution is doing something or other. I have here an amalgamated zinc plate, such as I had at the last lecture, and here a small platinum plate, and they are joined together by a long wire. Here we have a magnet very finely suspended, and the two ends are marked by different colours. The magnet is placed just over the sulphuric acid in this glass vessel, and is now taking the position of the magnetic meridian. I put in the two connected metals, one on one side, and the other on the other. Let us see what the magnet does. It at once turns round. There, it begins to swing—to turn away from its position, just as our magnet was turned out of its place in the last lecture by means of the wire. You may take my word for it that the magnet was not turned out of its place by a wire in the present instance, but that it was what was

passing in the liquid itself which affected the magnet. Here is an arrangement in which the liquid itself is in a long tube that winds round a magnet; and we shall find that this long tube is capable of deflecting the magnet, just as the wire deflected it on a former occasion. Thus, then, we see that there is something taking place in the liquid itself. It is not necessary, in these experiments on the replacement of metals, that the junction within should be the liquid itself. If the junction between the copper and the zinc were outside, the result would be the same. Here is a plate of copper, and here a little wire of silver. The copper is in nitrate of copper, and the silver is in nitrate of silver, and the arrangement has been standing for some time. I will just take the two metals out. You see they have been joined by this wire at the top. There has been no acid used here, but each plate has been in a solution of its own salt—the copper in a copper salt, and the silver in a silver salt; and the two liquids can get at one another through a porous diaphragm. You see that beautiful display of crystallised silver. Some of the crystals which are formed in that way are among the finest possible. Here is an instrument which Mr. Tribe and I have made for some experiments of our own. Its internal construction cannot be seen, for it is not of glass as the other was; but there you perceive the beautiful forms of lead upon the leaden plate. Some of the lead has dropped as I have been lifting it up. Probably if it is put in the ray of the lamp you will see the forms better. There are the lead crystals, or, more properly, leaves of lead. Just to show you that there is a current passing through this wire, as well as a current inside, I will pass the wire along the suspended magnet, and I dare say—without the loss of a moment—we can make it clear. Now you see that it has made the magnet start, and if I remove it the magnet falls back again. There is some change then—some strange force that is going all round this wire, such as was going round the wire that you saw at the last lecture; and, as I showed you just now, there is a similar force going through the liquid itself. Now what is it that takes place? I told you that every liquid decomposed in this way was a salt or acid, and was formed of two parts. It is made of a metal, and something besides the metal—the sulphuric element, or whatever it may be. Now, how are we always to get the metal to one particular place? Is there a sort of constant pelting of the metal through the liquid? No, nothing of the kind. There is not a single particle of metal going through the liquid in that way. And when the hydrogen formed upon the copper plate, while the zinc dissolved, you did not see the hydrogen flowing from the zinc plate to the copper plate. Then how does it get there? Well, I will try to show you how, but I do not know whether I can make it at all intelligible to you; but, if the time will only allow me, I will try. I have endeavoured to illustrate it in this way. We will take a series of balls, in pairs, and we will suppose that each pair is composed of copper and the sulphuric element. We want to know how it is we can have the copper always going off—always separated at the one end. These red balls represent the copper, and the yellow the sulphuric acid, and the blue represents zinc. We can easily imagine that the zinc should exercise some kind of push, or stroke, or vibration, which shall go through the liquid, and cause the copper to fly off at the other end. But what is to happen next? We take another zinc ball, and begin to act in the same way; but in this case it will be the sulphuric element going off next at the other end. Well, we must suppose that there is some change of position, and that, instead of the sulphuric element being ready to fly off at the next stroke, there has been a turning round, such as I am making with these coloured balls by means of my hand, and then at the next stroke of the zinc it will be another copper ball that flies off.

We can imagine such an alternation taking place each time, and so we can get all our copper sent off at the one end. [The action in question was further illustrated and explained with the aid of a working diagram constructed of paper.] I might illustrate it, also, by the way in which you sit upon these seats. Suppose you were under some potent obligation always to keep arranged alternately boy and girl, and yet it were necessary that all the boys on the bench should come out at one end of it: it could be managed by each girl and boy changing places at each move, and a fresh boy from another quarter coming in at the other end of the bench as a companion to the last girl, in the place of the one that had passed on. But I think I have said sufficient to indicate my meaning, and to give you some conception of how these metallic crystals may grow up. It is about the most difficult matter that I shall have to bring before you during the whole course—to make you understand at all what is taking place in these liquids; but the phenomena themselves are exceedingly beautiful, and you will have an opportunity of seeing some of the crystals under the microscopes outside, and you will be able to repeat many of the experiments at home. I hope that if you find any difficulties in doing so you will come to me, and ask me to explain more fully the experiments which I have brought before you to-day.

THE ROYAL INSTITUTION.

Dr. Tyndall has just commenced a course of lectures on subjects connected with electricity, which are delivered and illustrated in the way characteristic of that unrivalled lecturer. We have much pleasure in giving the notes of the first lecture. The rest will follow in due course. Professor Tyndall's illustrative experimental apparatus was of the simplest character. His electroscope was a light lath about three feet long, balanced on the rounded end of an egg. The effects of repulsion were shown by suspending with long silk thread two india-rubber balloons—children's toys—close to each other, and exciting them with the hand. His sources of electricity were glass jars, native amber, rock crystal, india-rubber, ebonite combs, gutta-percha, &c. The conduction of the human body was shown by the suspension and insulation of his active and able assistant, Mr. Cottrell, whose nose, to the great amusement of the audience, was made the attractive point of a light balanced scale. Many of the experiments were historical, and all were of that simple character which admit of easy repetition at home.

Notes of a Course of Seven Lectures on Electricity.
By Professor Tyndall, LL.D. F.R.S,

Lecture 1. *February* 4, 1875.

1. Many centuries before the Christian era it had been observed that yellow amber (*Elektron*), when rubbed, possessed the power of attracting light bodies.

2. The human mind soon began to show its discontent with the mere fact of observation, desiring something beyond it. What, it was asked, was the cause of this power in rubbed amber? Thales, the founder of the Ionic philosophy (B.C. 580), imagined the amber to be animated by a kind of life.

3. So matters remained for nearly 2200 years. In 1600 Dr. Gilbert, physician to Queen Elizabeth, whose attention had been successfully devoted to magnetism; passed from it to electricity. He showed that not only amber, but various spars, gems, fossils, stones, glasses, and resins, exhibited, when rubbed, the same power as amber.

4. Robert Boyle (1675) suspended rubbed amber, and proved that it, which attracted other bodies to itself, was in turn attracted by a body brought near it. He also observed the *light* of electricity, a diamond with which he operated being found to emit light when rubbed in the dark.

5. The tendency to physical theory showed itself in Boyle. He imagined that the electrified body threw out a glutinous or unctuous effluvium, which laid hold of small bodies, and in its return to the source from which it emanated carried them along with it.

6. The human mind was at this time in the condition of a wound-up spring from which the detent had been removed. The desire and capacity for investigation came suddenly into play. Otto von Guericke, contemporary of Boyle, and inventor of the air-pump, augmented the electric power previously obtained, and devised the first electrical machine, which was a ball of sulphur about the size of a child's head. His sphere of sulphur turned by a handle and rubbed by the hand emitted light in the dark.

7. Von Guericke also noticed that a feather, after having been once attracted towards his sulphur globe, was afterwards repelled and kept at a distance from it, until, having touched another body, it was again attracted. He also observed the hissing of the "electric fire," and that a body brought near his excited sphere became electrical, and was attracted by another body brought near it.

8. The members of the Academy del Cimento examined various substances electrically, proving smoke to be attracted, but not flame. Flame, they found, deprived an electrified body of its power.

9. They also proved fluids to be sensible to the attraction of amber; showing that an eminence was formed when rubbed amber was brought over the surface of a liquid, the liquid being finally discharged against the amber.

10. Sir Isaac Newton rubbed a flat glass, and caused light bodies to dance between it and a table. He also noticed the influence of the rubber in electric excitation. His gown, for example, was much more effective than a napkin. Newton imagined that the excited electric emitted an elastic fluid which penetrated glass.

11. Electric light *in vacuo* was first observed by Picard in 1675. While carrying a barometer from the Observatory to the Porte St. Michel in Paris, he observed light in the vacuous portion. Sebastien and Cassini observed it afterwards in other barometers. John Bernoulli devised a "mercurial phosphorus," by shaking mercury in a tube which had been exhausted by an air-pump. This was handed to the King of Prussia—Frederick I.—who awarded for it a medal of forty ducats value. The great mathematician wrote a poem in honour of the occasion.

12. In 1705 Hauksbee made some celebrated experiments on this subject before the Royal Society. He also observed light in vacuo produced by the approach of an electrified body to an exhausted glass globe, and remarked on the colour of the light.

13. Dr. Wall (1708) operated with large elongated pieces of amber. He found *wool* to be the best rubber. "A prodigious number of little cracklings" was heard on rubbing the amber, and every one of them produced a flash of light. By holding one's finger at a little distance from the amber, a large crackling was produced, with a great flash of light succeeding it. "This light and crackling," says Dr. Wall, "seems in some degree to represent thunder and lightning." (*Phil. Trans.*, 1708, p. 69.) This was the first allusion to thunder and lightning in connection with electricity.

14. Stephen Gray (1729) experimented with a glass tube stopped by a cork. When the tube was rubbed the cork was found to attract light bodies. "Much surprised," Gray "concluded that there was certainly an attractive virtue communicated to the cork." This was the starting point of our knowledge of electric conduction.

15. A fir stick, four inches long, and stuck into the cork, was also found to attract. Gray first lengthened his sticks and then passed on to packthread and wires. Through the thread from the top window of a house he attracted light bodies at the bottom. Suspending a hempen line by loops of packthread, he failed to transmit the electric power. Suspending it by loops of silk he sent the "virtue" through 765 feet of the line. He thought the silk effectual because it was *thin*; but on replacing a loop of it, which had broken, by a still thinner wire, he obtained no action. Finally, he came to the conclusion that his loops were effectual, not because they were thin, but because they were *silk*. This was the starting point of our knowledge of insulation.

16. Gray also found that the mere approach of an excited tube was sufficient to produce attraction at a distance. This action will subsequently be considered under the head of *electric induction*. He experimented on fluids and on animal bodies, using in the first instance soap-bubbles formed of Thames water, and in the second a boy suspended by hair lines in a horizontal position. He was not aware of the part played by moisture in his rods, lines, and tissues.

17, Gray suspended pokers, tongs, and fire-shovels by silk strings, and electrified them. To facilitate the process he attached to them tassels of thread, and these simple devices led up to the prime conductor of the electrical machine. Gray also observed the electric brush, snappings, and sparks, and makes the prophetic remark that "though these effects are at present only minute,

it is probable that in time there may be found out a way to collect a greater quantity of the electric fibre, and oonsequently to increase the force of that power: which by several of those experiments, if we are permitted to compare great things with small, seems to be of the same nature with that of thunder and lightning." This is much more definite than Dr. Wall.

Stephen Gray was dying when his last experiments were made. Unable to describe them himself, he dictated an account of them to Dr. Mortimer, Secretary of the Royal Society, the day before his death.

18. Du Fay (1733 to 1737) extended the list of "electrics" (the name given to bodies capable of being electrified). He established the influence of moisture, and conducted the electric power through 1256 feet of moist packthread.

19. Stephen Gray obtained *attraction* through the human body. Du Fay first obtained a *spark* from a human body. He tried to fire gunpowder and inflammable substances by this spark, but failed.

20. Du Fay announced the important discovery that there are two kinds of electricity. Gold leaf, floating in air, he found to be first attracted, then repelled by the same body. When repelled by rubbed glass it was attracted by rubbed resin, and when repelled by rubbed resin it was attracted by rubbed glass. Hence the terms *vitreous* electricity and *resinous* electricity. Du Fay proved each of them to be self-repulsive, while attractive of the other. This is the fundamental law of electric action.

21. To ascertain the kind of electricity with which a body is charged, Du Fay adopted the correct test of repulsion. Attraction is not a safe test.

21. Dr. Desaguliers (1741—42) made many sagacious observations and remarks on electricity. He found that he could electrify a wax candle, but that near the flame the electricity disappeared. He ranked pure *air* among his electrics.

23. It is now time to say that the distinction between electrics and non-electrics is really a distinction between insulators and conductors. The conductors being held in the hand and rubbed, the excited electricity immediately escaped, while it was retained upon the surfaces of insulators. When properly insulated the most perfect conductor can be electrified by friction.

ROYAL TELEGRAPHING.

The Queen's speech is the great telegraphic event of the year. Telegraphists all over the country vie with each other in their eagerness to rapidly transmit the royal utterances at the opening and the close of the parliamentary session; and the trials of speed at the Central Station in London are regarded as the "Derby" of telegraphy. It was so in the old days of telegraphic communication, when the speech used to be signalled on the double needle instrument, and had to be let down by very easy stages indeed, when it was destined for distant towns in the North of Scotland, or the West of England, or for Ireland. Perhaps, indeed, it might have to be re-transmitted three or four times before it reached Aberdeen, and at least twice on its journey to Plymouth. Last Friday week it was signalled *direct* from the Central Station to Aberdeen and Falmouth: to the former place within the short space of twenty minutes, and to the latter in exactly half that time. It is questionable if, in the early days of telegraphy, the Queen's speech would be sent to such a place as Falmouth at all. The enormous enterprise of the press, and the vast development of the telegraphic system, have rendered a good many things both necessary and practicable which were in those days deemed impossible. For instance, the Queen's speech of the other day was transmitted to no fewer than 183 towns throughout the United Kingdom; and lest any one should suppose that these were only the important centres of commercial activity or political thought, let him consider that such places as Oban, Campbeltown, Peterhead, Wick, Thurso, and Tralee, were amongst the number. To nearly 60 out of the 183 towns referred to, the speech was signalled *direct* from London; and to the remaining 120 or so it would be completed with, in most cases, only a single re-transmission. The work of signalling commenced at 2.8 p.m., that being the moment at which the signal to "start" was received from the House of Commons. In a twinkling, the fingers which had been nervously grasping their "keys" for some minutes came down in the shape of "dots" and "dashes" to the tune of 40 words a-minute or more; and the Wheatstone transmitters, wound up to the highest pitch of eagerness, were let loose with their familiar "whirr." While we were only as yet looking on to see what it all meant, "Finished to Leicester" shouted one excited operator, and ditto to York shouted another at the same moment. This was at 2.14 p.m. to the moment; so that the 983 words of which the speech was composed were transmitted to these towns in six minutes, or at an average speed of nearly 10,000 words an hour! The great towns—Birmingham, Manchester, and Liverpool, and Nottingham, Sheffield, Leeds, and Bradford—received the speech simultaneously, on what are called the "express circuits," and to these the work of transmission was accomplished in the short space of eleven minutes. To Scotland and Ireland—including Aberdeen, Dundee, Belfast, and Cork—the speech was finished within twenty minutes; and to the great majority of places where the transmission was effected direct, within half-an-hour. By hand, on the ordinary Morse instrument, the speech was first finished to Brighton; but as two separate wires were employed in this case, the actual speed of transmission is not acurately determinable. The necessity for speedy transmission to Brighton is evident, if we consider that the telegraph has really to compete with the London evening papers, where the distance is so short, and the train service so swift. The absolutely quickest transmission by hand was to Southampton, Reading, and Bath, where a speed of 44 words a-minute, or upwards of 2600 words an hour, was attained. This, we may explain, is equal to about 75 ordinary telegraph messages an hour; although it is probable that abbreviations were largely resorted to, both in the hand and Wheatstone processes of transmission. We have said that the speech contained 983 words. Making due allowance for stops and punctuation, this represents 4800 letters; and any telegraphist with a statistical craze could easily tell us the number of separate movements involved in transmitting this quantity of matter. The word

"Paris" is usually accepted as the standard in such calculations; and working on this basis, it would be found that upwards of 50,000 separate holes would have to be punched on the Wheatstone slip before it was ready for passing through the transmitter, and that nearly 14,000 separate symbols would be recorded in ink at the receiving stations. Similarly, all the clerks who transmitted the speech by hand, would have to make 14,000 depressions of their keys, representing some 10,000 dots and 4000 dashes. It does not detract from the interest or the credit of the feat performed at the Central Station last Friday week that the operators concerned in the transmission of the Queen's speech were mostly drawn from among the young ladies of the establishment. There is, indeed, quite a pleasing appropriateness in the arrangement by which the gracious utterances of our most Royal Lady should be transmitted to the uttermost parts of her Majesty's dominions by female hands.

Notes.

We have to record, with much regret, the death, on January 23rd, of General Meydam, the Director-General of Telegraphs of the German Empire.

General Eckert, who visited Europe two years ago with Mr. Prescott, has suddenly resigned the General Superintendentship of the Western Union Company's lines, in America. He is about to manage, as President, the Atlantic and Pacific Telegraph Company's business, the chief competitors of the Western Union Company; and it is reported that a great and bitter telegraphic contest is about to commence in that country between these rivals.

One of our London contemporaries heads its short condensed summary of news with the following specimen of Neology:—"Telegraphized News Notes."

The Eastern Telegraph Company have just opened a new route to Egypt across France, *via* Marseilles and Malta. They have leased a special wire for this purpose from the French Government.

We learn from the *Athenæum* that "Attention has been called by M. Max Paulet to the destruction of wooden railway-sleepers, laid in ballast, in spite of attempts to preserve the wood by injecting sulphate of copper. His experiments tend to show that the action of this metallic salt on the ligneous tissue produces a compound which is not absolutely insoluble in pure water, and is soluble to a notable extent in water charged with carbonic acid. After having lain for some time near the iron rails, the wood was found to contain a considerable proportion of iron, whilst away from the neighbourhood of the rails the carbonate of lime derived from the ballast took the place of the copper-salt; and although the lime-compound is not itself a septic agent, it yet acts prejudicially by removing the preservative medium. From these results it appears that wood thus prepared is far from being a durable material for construction of permanent way." This fully confirms the experience of the Boucherising process upon telegraph poles in England, especially in the chalky districts. We give an abstract of M. Paulet's paper at p. 48.

We have pleasure in calling the attention of our readers to a course of fifty lectures, on Electricity and Magnetism, which are being delivered by Prof. Foster at the University College, and which are advertised in our first page.

The cable between England and Guernsey was repaired on the 7th inst.

The cable between the Lizard, Cornwall, and Santander, in Spain, is broken down, and the *Caroline*, one of Mr. Henley's ships, which is on the spot, is about to repair it.

Many of the officers of the late Electric and International Telegraph Company will be glad to learn that their old friend and colleague, Mr. H. Shütz Wilson, is continuing to gain laurels in the pleasant fields of Literature for which, at the transfer, he gave up the rougher paths of Telegraphy. His "Studies and Romances," published by King and Co., and "Philip Mannington," a novel published by Tinsley, are rapidly running through their first edition, and are much sought after at Mudie's, Smith's, and other libraries. Many will remember Mr. Wilson's early productions, published twenty years ago, in that pleasant and creditable but very scarce publication *Our Magazine*, produced entirely by officers of the Electric and International Telegraph Company.

The Chinese authorities are only now about to commence mining operations in the very locality referred to in an ancient Chinese history, some 2000 years old, as being the spot where the loadstone was first discovered in China.

The following story is going the round of the papers:—A clerk in the Telegraph Office, No. 145, Broadway, New York, the other day received a message from Philadelphia for him to transmit to Paris. It had to be sent *via* Duxbury in the usual way, whom he could not make to hear. So he wired to Plaister Cove, Newfoundland—"Please wake my dear colleague at Duxbury." The Plaister Cove clerk telegraphed to Valentia, in Ireland, who telegraphed to London, *and thence to Paris* (!), thence to St. Pierre, and thence, at last, to Duxbury, and this time the drowsy operator was aroused. We have seen this story in other forms before.

Scientific men who read the *Times*—and who does not?—must have observed the prominence which that paper is now giving to scientific intelligence. Its Parisian correspondent is very observant and instructive, and its telegraphic information generally is of the very first order, and is most ably written.

The Union Steamship Company's steamships *Asiatic*, *African*, and *Anglian*, sailing from Plymouth on the 6th, 16th, and 26th inst., respectively, will touch at Madeira, on the outward voyage, for the purpose of receiving on board telegrams addressed to places in Cape Colony.

ON THE CONSTRUCTION AND MAINTENANCE OF LIGHTNING CONDUCTORS.

By R. FRANCISQUE MICHEL.

Most of the lightning conductors of Paris have been neglected for so many years that they are positively dangerous instead of being useful protecting apparatus. Examined with a very strong magnifying glass, the points of the stem are blunted or burnt (a criterion of the bad condition of the communications), and the points have fallen from several—or rather, having been badly joined, the solder has failed, and they only hold together by the pins; the vibrations of the stem when agitated by the wind has worn away the connections, so that a great number are easily shaken by the hand. The contact is very bad, and consequently the preventive effect of the apparatus is absolutely null. But these great deteriorations are not confined to the stems, since the point of juncture of the conductor to the base of the stem is almost everywhere in a deplorable state. This juncture I have always found to have been made with a strap or iron collar, whose pieces are rusted, so as to render the electric communications next to nothing.

I have found the conductor, in general, composed of lengths of iron, of 15 m.m. square section, maintained in position against the buildings by cramps driven into the walls, and rivetted to the conductors, thus weakening them at certain points, and also increasing their electric resistance. The different lengths are jointed by means of a pyramidal bolt let into a notch of the same form, and, by a simple pin, their contact is deemed to be rigidly maintained.

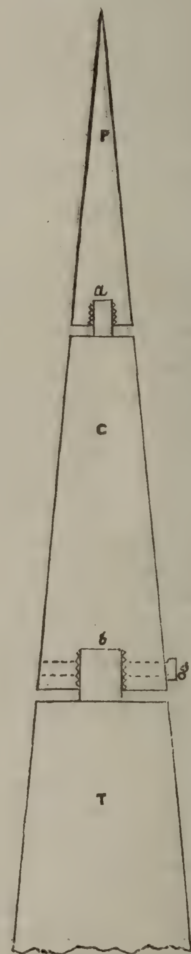
In the first place, conductors, which often attain very considerable lengths, dilate and contract in consequence of differences of temperature.* These variations strain very considerably the braces (rivetted as they are to cramps, and fastened to the walls), by causing the conductor to bend, and thus frequently the fastenings are torn out, to the general derangement of the entire apparatus. As regards the earth communication they are in no better condition: their resistance, measured by one of Wheatstone's bridges, is always much too considerable. I have even met with instances in which the conductibility may be considered null.

* In our climate the bars of the conductor may attain, in the hottest summer sun, a temperature of about 60° C.; during winter it may be as low as – 20°, representing a difference of about 80°. For such a variation the bars of iron may lengthen 1-1000th, say 1 centimetre for 10 metres.

These conductors may still be rendered useful and sound by repairing them in the following fashion:—

The Stem.—The old stems, if they are not too deeply eaten away with rust, and are made of one piece, may be used again, by subjecting them to the following modifications:—The platinum point so much extolled is not indispensable. One of red copper, or, better still, an alloy of 835 parts silver and 165 parts copper, may be substituted. Then the arrangement shown in Fig. 1 may be given to the stem.

Fig. 1.

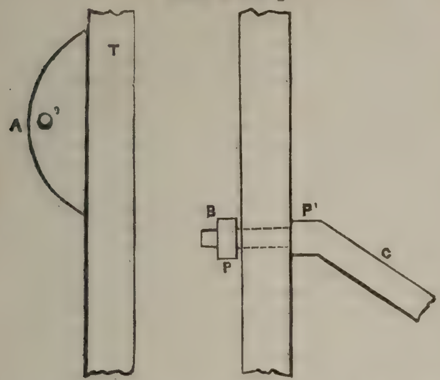


C is the trunk of a red copper cone, upon the top of which a pinnacle, P, of platinum, or copper and silver alloy, should be screwed, pinned, and strongly soldered at *a*, the whole to be screwed on to T at *b*. Then, to ensure thorough contact, I propose to insert between C and T, a kind of washer of freshly scraped lead, and to cover the entire joint with a thick layer of solder.

The Conductor.—I said that the point where the conductor joined the stem was always in a deplorable condition. The following re-arrangement presents many serviceable features. At a little above the base of the stem, say about 20 centimetres from

the roof of the building, let a flange, A, be welded, with a hole pierced through it. Through this hole the conductor, previously filed down to the proper dimensions, must be tightly passed. After scraping the iron around the hole, a washer of lead is placed

FIGS. 2 AND 3.



at P and P′, and the button B, with the help of a strong layer of solder, thoroughly binds everything together. By this means an excellent joint is obtained; the contact surface is considerable, and completely protected from rust—a condition never hitherto fulfilled. If bars of iron are used for conductors, one cannot be too careful as regards their joints. That consisting of the pyramidal bolt and pin (formerly much used) is very bad, and should be entirely rejected. The jointing represented in Fig. 4 seems to afford good claim to dura-

FIG. 4.

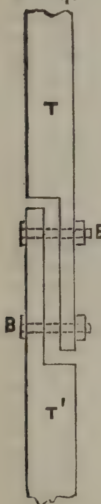
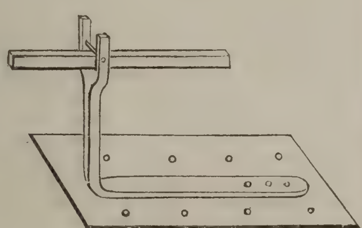


FIG. 5.

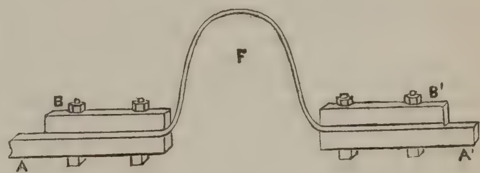


bility and good contact. On each end of the bars to be joined two flanges, about 15 c.m. long, and half the thickness of the bars, are filed out. A thin sheet of well cleansed lead is then placed between them. The whole is then firmly bolted together by bolts at B and B′, and covered with solder, thus furnishing a contact of great solidity, unlimited durability, and without appreciable resistance.

The Supports.—Instead of using rivetted cramps to hold up the conductor, a model (Fig. 5) laid before the Academy of Sciences answers perfectly as a substitute. It is simply a fork in which the conductor is held fast by a pin. Being allowed to slide backwards and forwards in the fork with great facility, the conductor is allowed to dilate or contract under the influence of temperature without threatening the supports with destruction. Upon what part, however, ought the effect of such contraction or dilation to be borne?

The Compensator.—This instrument is the part designed to bear the strain, and the Academy of Sciences has proposed its use. A sketch of it is given below.

FIG. 6.



It is composed of an elastic plate, F, of red copper, well annealed—2 c.m. wide, minimum length 70 c.m., and 5 m.m. thick. The two extremities of this plate are firmly fastened to the end of the conductor-bars by the bolts and counterpieces, B B′, and afterwards well covered with a firm layer of solder. When, in consequence of heat, the conductor expands, the curve of the plate F will become greater, and *vice versâ.* As to the places where they should be placed the architect will be the best judge. In general a single apparatus compensates for the effects produced by long straight lengths, and it will therefore suffice to place one at each bend. Since it is important to preserve the metallic parts of the conductor from contact with the air, it might be profitably coated all over (except the copper and alloy portion of the stem—C P, Fig. 1) with a strong coat of tar, a painting of zinc or tin filings, or a painting of metallic basis, which could afterwards be covered with another coat of more suitable colour.

Earth.—I have almost always noticed the serious fault that where the conductor penetrates the soil it is not covered with any protecting substance; so that the alternations of dryness and moisture in the soil deeply corrodes the iron, and ultimately eats it entirely through. The remainder of the underground portion of the conductor is also always in a deplorable state.

The first inconvenience may be remedied in many ways: The use of a vertical spout of tarred, boucherised, or creosoted, wood, rising a few centimetres above the soil, has long been proposed; but is it not more simple to surround this small part of the conductor with a wrapper of sheet lead? This portion of the conductor may even be well tarred, but only for a short distance, simply as far as the place where it makes a bend to enter the trough through which it reaches the sheet of water or other terminal. To guard against the second inconvenience—that affecting the portion of the conductor which winds about underground—the Academy of Science advises the use of a trough filled with broken charcoal (*braise de boulanger*), through which the conductor runs. This charcoal prevents a too rapid oxidation of the iron. Coke, well piled up, may be substituted for it; and for the trough injected wood or gutter tiles will suit admirab

When the trough has to bear a considerable pressure it may be made of bricks, without mortar, to allow the moisture of the soil to readily penetrate. It is preferable, although the conductor be lengthened, to carry it through the dampest plots of ground around the building.

(To be continued.)

Proceedings of Societies.

SOCIETY OF TELEGRAPH ENGINEERS.

Inaugural Address, by Mr. Latimer Clark, President. January 13, 1875.

(Continued from page 33.)

In 1819 Œrsted discovered the effect of the current in causing a deflection of the magnetised needle; and in 1820 Ampère proposed to construct a telegraph by means of the voltaic battery, the coil of wire, and the magnetised needle. This was followed by the long series of Faraday's wonderful electrical researches.

In 1827 Dr. Jacob Green, of Jefferson College, Philadelphia, wrote as follows:—"In the very early stage of electro-magnetic experiments it had been suggested that an instantaneous telegraph might be constructed by means of conjunctive wires and magnetic needles. The details of this contrivance are so obvious, and the principles upon which it is founded are so well understood, that there was only one question which could render the result doubtful. This was, whether by lengthening the conjunctive wires there would be any diminution in the electrical effect upon the needle. . . . Had it been found true that the galvanic fluid could be transmitted in a moment through a great extent of conducting wire without diminishing its magnetic effect, then no question could have been entertained as to the practicability and importance of the suggestion adverted to above with regard to the telegraph. Mr. Barlow, of the Royal Military Academy (at Woolwich), who has made a number of successful experiments and investigations in electro-magnetism, fully ascertained that there was so sensible a diminution with only 200 feet of wire as to convince him at once of the impracticability of the scheme."

There can be little doubt that this published opinion of so eminent a man as Prof. Barlow, which occurs in the *Philosophical Transactions*, had the effect of retarding the introduction of electric telegraphs by many years.

In the same year Ohm published the celebrated mathematical formulæ which bear his name, and had they been known and duly appreciated at the time they would at once have dispelled all misgivings as to the distance at which electrical effects might be rendered sensible. They were not, however, translated into English until 1841.

In 1828 Green, of Nottingham, published his valuable mathematical investigations of the distribution of electricity on the surface of conductors of various forms.

In 1834 Wheatstone immortalised his name by his magnificent experiment on the velocity of electricity, and by his other researches on the subject, which doubtless caused many minds to ask themselves, as Ronalds had done, "Why has no serious trial yet been made of the qualifications of so diligent a courier?"

We now approach the memorable epoch of 1837. cientific men were in possession of every knowledge and appliance necessary for creating a perfect electric telegraph; the subject was commonly lectured on; fresh methods of communication continued to be invented, among which I will only mention that of Baron Schilling, who, in 1832, employed five wires insulated by silk, and five vertical needles.

Railways had also now come into extensive use, and the world was in every way ripe and ready for the practical introduction of the telegraph. In March, 1836, Mr. Wm. F. Cooke appears to have been present at one of these public lectures, and, struck by the adaptability of the telegraph to the requirements of railway traffic and commercial use, at once made the subject his exclusive study. Returning to England, on the 22nd April, he appears to have devoted the remainder of the year to the study of the subject and the perfection of his ideas, the most important feature of which appears to consist in the fact that he for the first time introduced the use of an electro-magnet for telegraphic purposes. His first model, made out of a musical snuff-box with an electro-magnetic escapement, was made at Heidelberg. He first exhibited an instrument of this form to Prof. Faraday in November, 1836, and subsequently to the Directors of the Liverpool and Manchester Railway, in January, 1837, with a view to its adoption on the incline of the Liverpool Tunnel, which was then worked by a rope and a fixed engine. The instrument gave sixty signals, and was considered too novel and complex for the purpose required; and, before simpler instruments could be constructed, they adopted a pneumatic telegraph.

We now arrive at the epoch of 1837, the year in which the first practical telegraphs were introduced. Several electric telegraphs were invented during this year, any of which, in the absence of others, would, without doubt, have laid the foundation of the practical telegraph. Among them those of Cooke, Wheatstone, Morse, and Steinheil require especial mention. The telegraph of Prof. Steinheil deserves notice on account of its great ingenuity and completeness. He employed only one wire, and transmitted his signals either by sound or by an alphabet of dots printed on a strip of paper, and he employed the earth circuit. His experiments were performed on a distance of several miles between the Royal Academy at Munich and Bogenhausen, and his telegraph was certainly very far in advance of any other existing at that date. His system was not, however, brought into further use at that period.

In February, 1837, Mr. Cooke, by the advice of Prof. Faraday and Dr. Roget, made the acquaintance of Prof. Wheatstone, and in June they had formed a partnership and taken out a joint patent. Much difference of opinion has arisen as to the due apportionment of the merit of these gentlemen in connection with the invention or introduction of the electric telegraph; but it is not our purpose to-day to inquire into the merit of these respective claims. Happily, abundant documentary evidence exists to enable those who take an interest in the question to form their opinions upon it. It appears to me, however, that neither of those gentlemen can in any sense claim to have been the inventor of the electric telegraph. In fact, if we except the use of the electro-magnet and the mechanical escapement, I do not find, in their inventions of this period, any important novelty of combination or of principle which appears likely to survive in that process of "natural selection," that "struggle for existence," which goes on as persistently among the productions of art as in the province of Nature. Their claim for distinction must rest rather on the energy and success with which they introduced their system into practical use, and compelled the world to recognise its merits.

By the deed of partnership executed between these gentlemen it was arranged that Mr. Cooke was to continue the entire practical management and control of their affairs, and accordingly, on the 27th of June, Mr. Cooke was introduced to Mr. Robert Stephenson, who at once took the greatest interest in the invention,

and lent it all his influence and assistance. It is gratifying to find the name of one of the fathers of the railway system thus early acting as a father to the electric telegraph.

On the 4th of July the apparatus was exhibited to Mr. Stephenson, and by the 25th their first experimental line was in operation between Euston and Camden, and was worked in the presence of Professor Wheatstone, Mr. Stephenson, Mr. Charles Fox, Mr. Brunel, and Sir Benjamin Hawes.

The system exhibited was still that of the electro-magnetic escapement and rotary dial,—the needle telegraph, which has been since so intimately associated with their names, not having been yet perfected.

At the same time Prof. Morse was occupied in introducing his electro-magnetic telegraph in America. This telegraph, from its exquisite simplicity, has come into universal use throughout the world, and has conferred immortality on the name of its inventor. The idea had long existed in his mind, and as early as 1835 he had exhibited his experiments to private friends, but there appears no published record referring to his invention earlier than a letter in the *New York Observer* of April 15, 1837, by his brother, S. E. Morse, and in this letter he speaks of the invention as requiring twenty-four wires. On the 10th of March a circular letter had been sent to certain collectors of customs and others desiring information with reference to telegraphic communication, and it was this circular which probably evoked the letter in question. On the 27th September Prof. Morse wrote a letter to the Secretary of the Treasury of the United States, which shows that he had allowed the subject to lie dormant, but he promised to have a complete apparatus in operation by the 1st January, 1838. His first experiment, over half a mile, was made on the 2nd October, 1837, and on the 6th October he filed a caveat in the patent office at Washington. I believe the first working telegraphic line erected in the United States was that between Washington and Baltimore, which began work in 1844.

(To be continued.)

Notices of Books.

A Manual of Telegraph Construction: the Mechanical Elements of Electric Telegraph Engineering. By John Christie Douglas, East India Government Telegraph Depôt, &c. London: Charles Griffin and Company. 1875.

That a manual of telegraph construction is a want which has been long felt will be admitted by every one who is in any way connected with the subject; and since the first announcements of Mr. Douglas's work appeared, we had hoped to find that, upon its publication, this desideratum would be at last supplied. We regret to state that our hopes have been disappointed. A work containing 420 pages of closely printed matter has now appeared, professing to deal with the subject; but less than 100 pages have been devoted to the treatment of it. Yet it is not to the amount of matter that we should object—for there is certainly here enough, and more than enough to satisfy even the most ravenous appetite in that respect. What we do object to is the fact that so much unnecessary extraneous matter is introduced: over 115 pages are devoted at the outset to "The General Principles of Strength and Stability," whilst over 200 follow upon the "Properties and Applications of Materials: Operations and Manipulations," leaving less than 100 for the subject of "Telegraph Construction: Maintenance and Organisation." The plea which Mr. Douglas advances for this is that "it is necessary that he (the telegraph engineer) should know the principles on which such, *i.e.* very complex frames, roofs, &c., extensive works in brick or cut stone, are built, to enable him to construct plinths of stone, and of brick with stone copes, and to fasten posts, cantilevers on, and in work built by others." Admitting this necessity, all the information required might have been condensed into one-third at the outside of the space which it is here spread over; the general principles on which he lays so much stress might have been clearly stated and briefly explained; whilst a large mass which has been most assiduously collected to form a volume might have been left in the works from which it is drawn. A reference from time to time might have been made to one or other of the numerous authors to whom Mr. Douglas expresses himself indebted. Conspicuous by its absence from the list of these is Mr. Culley's name. Although, strange to say, we meet with it no fewer than nine times—and then mis-spelt, by the way, on every occasion—is a single paragraph (No. 332) upon the subject of iron wire.

The general plan of the work can be gathered from the titles which have been already quoted of the three parts into which it is divided. That it contains a deal of useful information no one will be disposed to question; that it contains a deal more which is utterly superfluous will be admitted with equal readiness. Not the least objectionable feature in it is the slipshod manner in which the book is written. The sentences are as a rlue unnecessarily involved and complex; in many the subject is lost long before the end is reached, and almost all of any length require to be re-read before the exact drift of their meaning can be ascertained. In many of the paragraphs the same facts are stated over and over again, leaving upon the mind of the reader the impression that the author had written down the observations drawn from each successive work to which he referred, and had allowed them to remain so without any attempt to condense or mould them into a clear and compact statement.

Should ever another edition of the work be called for, we would advise Mr. Douglas to bring it within more modest dimensions, and endeavour to render the work intelligible enough to attract rather than repel the student.

Electrical Science in English and Foreign Journals.

Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences. No. 1. January 4, 1875.

A Note on Magnetism, à propos of a recent communication by M. Lallemand.—By the Count du Moncel.—Because it appears from a recent note by M. Lallemand (*vide* Telegraphic Journal, Nov. 15, 1874, vol. ii., p. 370) that, notwithstanding Count du Moncel's volume, numerous pamphlets, &c., his researches on the subject of magnetism, and magnetic condensation do not appear to be well known; he recapitulates the results he has at various times proved experimentally, in order to assert that he was the first to demonstrate years ago some of the phenomena M. Lallemand has written about. He says, among other things, I will commence by stating that the words *magnetic condensation*, which I was the first to use (possibly slightly improper), since it takes for granted in the phenomena an *increase* of magnetic energy which should maintain itself independently of the magnetising cause, but which, in reality, disappears with it, only giving place, *after* this disappearance, to a secondary magnetic action (variable according to the energy of the developed magnetisation), which has this time all the characteristics of a condensing action. Now it is precisely on account of this secondary magnetic action, and of the strengthening of this magnetic action itself, that I have

given the name of *magnetic condensation* to the phenomenon. We may indeed, in this action, meet with all the effects produced by an electric condenser. Thus the polarities excited on the surface of contact of two magnetic pieces, by reason of mutual reaction maintain each other after the magnetising cause has been removed; and to cancel the effect, it is necessary to separate the two pieces, or destroy one of the two polarities by an exterior contrary magnetism.

On the Decomposition and the Preservation of Woods.—M. Max Paulet.—It is generally admitted that the preserving action of metallic salt injected into timber is due to its combining with the ligneous tissue, and especially with the nitrogenous matter, whereby it is rendered insoluble and poisonous to organic creatures. *This explanation is insufficient;* for, from careful experiments with metallic salts, especially with copper, it is proved: (1.) That the albumino-cupric precipitate is not absolutely insoluble in water; (2.) That it is above all soluble in water charged with carbonic acid. The nitrogenous matter contained in ordinary wood is partly soluble and partly insoluble. The soluble albuminous portion is fixed by the metallic salt, which is thus united to the insoluble nitrogenous matter. Water, especially when charged with carbonic acid, dissolves and takes away the metallic agent. Recent experiments show that the reactions are not always so simple. The following is an instance of what is more often remarked: A "beech" sleeper injected with sulphate of copper, after having been buried for eight or ten years, is found to be rotten in several places. The altered parts are very brown in the neighbourhood of the rail; the wood is not worm-eaten, but chemically altered. If it no longer perceptibly contains copper, it does contain quantities of rail-iron. The fact of the iron penetrating into the wood, whilst in a state of dissolution, clashes with accepted ideas on the subject. The density of the wood is found singularly diminished. The difference in density between the sound and unsound portions are respectively 0·755 grain and 0·380 grain. The altered portion contains nitrogenous matter; it entirely dissolves in caustic potash; and, treated with water slightly nitrous, it gives up the lime it contains, as also a large quantity of iron. This iron, which could only have permeated the wood during its state of dissolution, is now insoluble; likewise, cyano-ferric solution of potassium, when applied to a chip of it, does not colour it blue. Whilst the nitrous acid takes away the iron, a prolonged disengagement of carbonic acid is perceived, a quantity much greater than contained in wood altered by exposure to the air. The explanation of the destruction of the wood is that the carbonate of lime contained in the ballast, and become soluble in an excess of carbonic acid, gradually penetrates the timber, at the same time driving out the copper. It suffices merely to measure the degree of alteration of the wood to determine the quantity of carbonic acid, or carbonates which it contains. The tenacity of the fibres is consequently inverse to the proportion of carbonic acid they contain. Carbonate of lime is not a septic agent, but by its combinations it eliminates the preserving action of the metallic salt, by interposing itself between the conserving matter and the matter to be preserved. In confirmation of this is the known fact that sleepers are rapidly destroyed in chalky ground.

No. 2. January 11, 1875.

On Stratified Light.—M. Neyreneuf. Herein the author desires to show by recital of experiments that a regular system of oscillations is in no way incompatible with the propagation of a rapid flow of heat and light, susceptible to energetic mechanical actions.

No. 3. January 18, 1875.

Contains nothing relating to the science of electricity.

Correspondence.

DERIVED CIRCUITS.

To the Editor of the Telegraphic Journal.

SIR,—In No. 43 of your Journal, published Nov. 15th, a formula is given for ascertaining the combined resistance of a system of derived circuits composed of three wires, two being joined at their extremities parallel to each other,—the third forming a bridge from one to the other, but connected at points of unequal potential so as to convey a current across the system from one parallel wire to the other. In such a case, how much is the combined resistance of the parallel wires lessened by the application of the cross or bridge wires?

It may interest some of your readers to know that a solution of this problem was given in a paper communicated to the Royal Society (No. 125 of 1871).

In the paper referred to, the solution is obtained without the assistance of Kirchoff's laws, and the formulæ are given for finding the shunt power for any particular branch in the figure.—I am, &c.,

HENRY C. MANCE.

Kurrachee, January 1, 1875.

Our Exchange.

ALL letters must be addressed to the publisher. The column is *free* to subscribers. Non-subscribers pay 6d. for each entry of twelve words, and 1d. for each additional two words. Price in figures counts as one word. Applications, accompanied with stamps and names and addresses, must be sent to the publisher. It is preferred that communication should, as much as possible, be maintained between seller and buyer.

The column is intended to be the vehicle of the expression of wants in books and apparatus, and of a means to supply those wants.

WANTED.

A good second-hand induction coil, giving not less than 6-inch spark; state lowest price.—Electro Magnet, 1, Home Road, Battersea.

Spon's "Dictionary of Engineering."—A 1.

Box of resistance coils.—A 2.

POST-OFFICE TELEGRAPHS.—Statement showing the total number of messages forwarded from Postal Telegraph Stations in the United Kingdom during the week ended the 30th January, 1875, and during the corresponding week of 1874:—1875, 339,733; 1874, 368,315; decrease in the week of 1875 on that of 1874, 28,542. The unusually high number of messages for the corresponding week of 1874 was caused by the preparations for the general election.—Week ended 6th February, 1875, and corresponding week of 1874:—1875, 342,892; 1874, 367,176; decrease in the week of 1875 on that of 1874, 24,284. The high number of telegrams during the corresponding week of 1874 was owing to the general election.

To Correspondents.

MR. EDEN, of Edinburgh, has addressed us on some remarks contained in Mr. Daniell's Address to the Telegraph Electrical Society of Melbourne, based upon a passage in one of Mr. Preece's lectures. The meaning is very clear — that those who make their business a profession are more likely to succeed than those who do not, and therefore pecuniary advantage must eventually accrue to those who study and think for themselves. Mr. Eden has only to refer to the officers of his own Department to find this proposition fully verified.

THE TELEGRAPHIC JOURNAL.

Vol. III.—No. 50.

FACTS AND THEORY.

The basis of all true knowledge is facts, and the foundation of all exact theory is the correct conception of these facts. A physical fact of itself is irrefragable; but owing to imperfect observation, to want of preparation in the mind, to unskilful manipulation, and to other causes, inferences from facts are often mistaken for facts themselves. Herbert Spencer has shown, in his "Sociology," how various biases of the mind tend to distort our judgment on social, political, and scientific facts, and he has himself given a notable instance in his own person, in this book, how a fine mind can be so prejudiced as to utterly ignore the results of experience. Hence it becomes essential to draw a great distinction between facts and inferences from facts, and to examine carefully theories to see whether they are based on the latter or on the former. There is a great tendency in the human mind to theorise. The idea to sift to the core, to reach at the very bottom of things, is intuitive. The observation of any effect, the learning of any fact, is instantly followed by the desire to know the cause; and if an explanation be not forthcoming, the mind at once seeks to arrive at its own conclusion. If this innate operation of the mind is allowed to act on the true conception of facts, we have what has been happily called the scientific use of the imagination; if, on the contrary, it acts on erroneous inferences from facts, we have the scientific abuse of the imagination. The latter condition is more frequent than the former. The result in the first case is true theory; in the latter case mere hypothesis, and often wild and injurious conjecture.

The various phases in the history of the theory of any science are very instructive. Facts remain fixed, but how the explanation of those facts have varied! The moon has continued to course around the earth, the earth around the sun, the planets retain their orbits as in the days of Hipparchus and Ptolemy; but how different the explanation of their movements as given by those ancient astronomers—and subsequently at different periods—by Copernicus, Kepler, Descartes, and Newton. The light from the sun, the twinkling of the stars, the colours of the rainbow, and the various hues of the floor of Nature, are the same now as when they gladdened the heart of Noah; but Euclid and the Platonists maintained that vision is exercised by rays proceeding from the eye, not to it; Newton conceived it to be due to excessively light particles of matter emitted from the luminous body impinging upon the retina of the eye; and Young has showed it to be due to the vibrations of an infinitely subtle and elastic medium, filling all space and permeating matter. Summers and winters warm and cool us now as they did of yore, food is cooked, water is boiled, metals expand, and fire levels our habitations to the ground as in the days when the burning bush attracted Moses. Yet while the incautious ancient thought that a boiling kettle into which he dipped his finger was a beast that bit him, even the modern has thought that heat was a form of matter, and the notion that it is a mode of motion is only now creeping into general belief.

Chemistry, within a comparatively recent period, has run through a complete cycle of changes. For twenty centuries the scientific world was satisfied with a belief in the existence of four elements,—earth, air, fire, and water. It then invented phlogiston, a kind of matter which being abstracted from a body actually added to its weight,—a veritable levitating medium,—to account for the composition and decomposition of substances. Lavoisier discovered oxygen, and introduced dynamical principles into the science. Dalton introduced the conception of atoms, and now we have the molecular theory established on as firm a basis as that of gravity or light.

The nature of Electricity is still wrapt in mystery, and the theory of its existence and action is mere vague speculation. Thales imagined excited amber to be animated with a kind of life; Boyle imagined an electrified body to throw out a glutinous or unctuous effluvium; Newton conceived that, in such circumstances, an elastic fluid was emitted; Du Fay, Franklin, and Symmer suggested various phases of the fluid doctrine, and now modern physicists are driving the theory through the same stages which caused light and heat to emerge from the material to that of the molecular or vibratory form. Thus we see that as our knowledge of facts increases, so does our perception of their true meaning improve, and so do our theories emerge from vague hypothesis to well-established doctrine. Theory based on inference or imperfect knowledge is a phantom of the scientific dreamer, but based on the true knowledge of facts it is the solid instrument of the philosophic explorer. Hence it becomes so essential that we should have a thorough knowledge of the facts before we attempt to theorise on those facts, and so important that we should resist the innate tendency of the mind to make use of the imagination in an unscientific groove.

THE VOLTAIC BATTERY.

A Course of Six Lectures,

By Dr. JOHN HALL GLADSTONE, F.R.S.,
Fullerian Professor of Chemistry, Royal Institution.

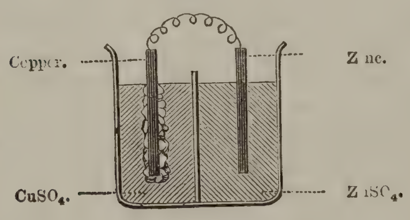
Delivered at the Royal Institution of Great Britain.—Christmas, 1874-5.

(Continued from page 40.)

Lecture III.—Electrical Decomposition.

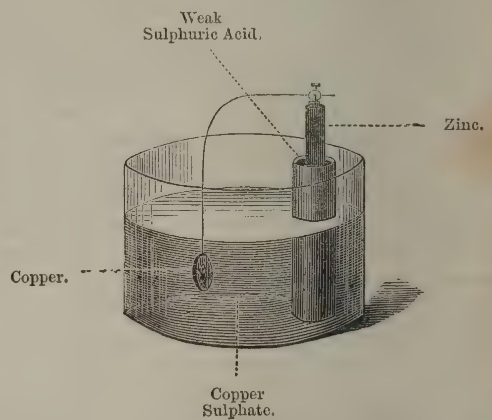
In my last lecture I spoke entirely of the replacement of metals, and I showed you, by such illustrations as could be exhibited on the screen, that there was a difference between metals with regard to their disposition to remain in combination, that one metal was capable of turning out another, and that we could arrange the metals in a long series according to their power in this respect. I showed that, when one metal was put into a solution, it turned out another metal, first by what was called chemical action or chemical affinity; but that what begins as a chemical act soon passes on to be a voltaic effect, and that, in fact, the new metal is deposited on the old metal at a distance. Now you saw this in a variety of ways; for instance, those branching crystals that we exhibited on the screen. I am very happy now to be able to hand you engravings of some of those beautiful crystals. I put at the end of the notes of the last lecture a statement that this replacement of metals was taken advantage of in certain arts. For instance, in the tinning of pins, and in the simpler sort of electrotypes. I had not time to speak of these two things, and the pins may very well be passed over; but I should like to say just a word about simple electrotyping, because it is in fact just the enlargement of what I showed you with the double cell. You

Fig. 1.



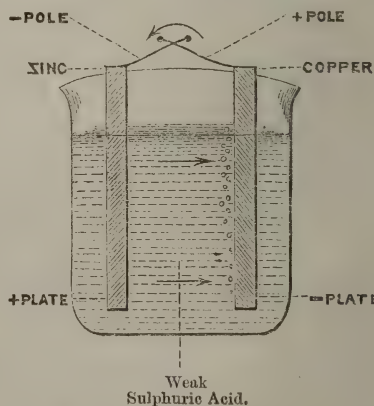
recollect how, in the divided cell, by putting zinc and copper plates into salts of those respective metals, we got the zinc continuously dissolved, and fresh copper deposited on the copper plate. Now this property can be taken advantage of in another way. Any of you can do it. You can take a porous cell, which is easily obtained, so as to separate one liquid from the other, and then you can take a piece of zinc, and fasten to it by a wire any copper medal or similar object; place the object to be copied in the outer vessel in a solution of copper, and the zinc inside the porous cell in a solution of sulphate of zinc, or sulphuric acid, and you can produce the effect you want. I will just set it working now, and at the end of the lecture we will take it out and see what it looks like. This is an arrangement which is employed actually for commercial purposes. We had a similar electrotype bath at work during the last lecture, and we produced this medal which I now hold up. [This was further illustrated by diagrams.] Now, in each of these cases you will find just the same action as in the formation of the silver tree, and in all similar decompositions. There is a change in the liquid. The liquid, as I said before, in all these cases, consists of two parts. It must always be what we call a binary liquid. We find a decomposition taking place, and in the cell before us the sulphuric element goes

Fig. 2.



to the zinc and combines with it, and the copper element is deposited on the copper. Now this is also the case in every kind of cell that I have already brought before you, and in every one that I intend to bring before you in the future. Here is a diagram representing the large cell which was placed in front of the table in the first lecture, and you will see that we have zinc which is coloured blue, and copper which is coloured red. These were immersed in weak sulphuric acid, and the two were joined, either by touching the metals together, or by means of a wire which is here represented. When this junction took place, a decomposition in the liquid ensued. This decomposition showed itself in various ways, but, among others, by the bubbles of hydrogen gas not appearing upon the zinc, but appearing upon the copper as they are represented here. These bubbles are supposed to be rising up in the liquid.

Fig. 3.



Now I want to introduce new terms to you. I have spoken of this liquid being split asunder, or divided into two parts in every case. I shall have

to use the words "positive" and "negative," perhaps, a good deal presently. We speak of these two metals as being positive and negative. We do not mean that they are of opposite characters exactly, only the one is what we call positive to the other; the one has a greater power than the other. One is stronger than the other, as I said in my previous lecture; and so we speak of silver as negative, and mercury as positive, because it is stronger than silver. The potassium is the strongest of them all, and therefore, of the metals of our list the potassium is the most positive, and the silver is most negative. You recollect how potassium will turn out magnesium, and magnesium turn out zinc, and zinc will turn out tin, and tin will turn out copper, and copper will turn out mercury, and mercury will turn out silver. That is the chemical meaning of the terms "positive" and "negative."

But suppose we look at it in another way, and we take these two different metals, and cause them to touch one another. We should find that by the mere contact of the two metals they get into opposite conditions one to the other. If I had pleased to make the experiment, I could have shown you that there was electricity produced by the touching of them together, and that they were in different electrical conditions. They have what electricians call different "potentials," and the one is positive to the other. I mean without any sort of liquid being between them at all. I have not, however, made any arrangement for showing it. That fact belongs rather to the physical side of the subject, and belongs to the course of lectures which Professor Tyndall has announced to deliver here in the course of the spring, and my department is rather the chemical side of this subject.

Again, every liquid that is split up is split up into two parts, which stand in the same relation of positive and negative to one another. So that when we have a splitting up of the sulphuric acid, the hydrogen is called the positive element, and the sulphuric element is called the negative element. In the cell the zinc is positive, and the hydrogen in the sulphuric acid being positive, it goes and joins itself to the negative, that is the copper plate. There is supposed to be a passage or current, and it is assumed that the movement is from the positive to the negative, and hence these little arrows that show the movement that takes place are represented as going from the positive towards the negative; and thus the positive metal or hydrogen is deposited against the negative plate. I said that if we make the two metals touch one another, we get them in these two conditions—positive and negative. If we examine them and see which is the positive and which the negative, we find just the same order as in the chemical series. Potassium is positive to magnesium; magnesium is positive to zinc; and so on. When liquids are employed the order depends a little upon the liquids; but still, if we employ the dry metals, we shall range them in the same order as in the list which was written on the blackboard at the last lecture.

Well, then, there is some force, no doubt, exhibiting itself in two ways, either as the chemical force or as the voltaic force. Now, if we have these two metals touching, we have a certain electrical effect produced. This electrical effect is capable of starting a chemical effect. I showed you in the last lecture that, when we had a chemical effect produced by replacement of metals, it started afterwards a voltaic effect. Did I not? Now, conversely, the two united metals being at a distance from one another, they will often start a chemical effect in the liquid between them. For instance, if we take perfectly pure zinc, or amalgamated zinc, and immerse it in sulphuric acid, there is no action between the two; but directly we join the zinc with the copper plate, we have an action produced between the two; so that we have, in this instance, a voltaic force producing a chemical force, and in the case of the branching crystals, chemical force producing a voltaic force.

But now I want to show you more fully that, when two metals do touch, they cause a splitting asunder of compound bodies. If I were to take a piece of zinc and a piece of copper, and keep them far apart in pure water, there would be no visible action; but suppose we make the zinc and the copper touch at a great number of places, we multiply the number of effects amazingly, and we decompose the water. This has been carried on in a great number of instances by Mr. Tribe and myself, and Mr. Tribe has kindly undertaken to superintend the experiments which I shall now show you.

This flask contains something which, at a distance I dare say, looks a very uninteresting black substance. It is zinc foil. There are two yards of this zinc foil crumpled up, and it has just had a little sulphate of copper poured over it. You understand what has happened. The copper is deposited of a black colour upon the zinc foil. This copper being deposited in fine crystals upon the zinc, touches the zinc in a million different places, and this causes a visible action upon the water. I had some pure water poured upon it, and it has been standing there since a quarter before three—now exactly half an hour. Here are the bubbles which are rising up. That amount of gas has been collected during that half hour. I will not say what it is just now. As the action goes on, I dare say we shall collect a great deal more. That is taking place at the ordinary temperature of the air. We will now take some at a higher temperature. We will take hot water instead of cold, and then see whether it does not act very much more rapidly. I may say that this decomposition of water is only a type of a great number of decompositions which we can produce. We can destroy a great number of other substances besides water in this way; for instance, chloroform, iodide of ether, and similar organic liquids. Mr. Tribe and I have worked them out, and found that two metals, in conjunction like this, are capable of splitting asunder these bodies and producing new compounds—some of these compounds being perfectly new to chemists, and not known before at all. Here is hot water poured upon the foil, and we will collect the gases in this little glass vessel. There goes the gas bubbling up much more rapidly than before Well, that experiment will take, I suppose, two or three minutes to collect any quantity. In the meantime, suppose I give you a little digression—a little episode.

I do not know whether you noticed at the end of the notes of the last lecture that there were some Latin words, and that I had spoken of the *Arbor Saturni* and the *Arbor Dianæ*—the tree of Saturn and the tree of Diana. I meant by the tree of

Saturn—the lead tree which, you remember, was standing on the table, and where the lead was growing about the zinc. The tree of Diana is the little silver tree, where the silver was built up upon the mercury. I do not know whether it will occur to any of you to enquire why they were called Saturn's tree and Diana's tree. It is a curious story, and if I were to tell you all about it, it would lead me a long way from the subject of the lectures. However, while the experiment is going on, I will just say a word about it. It belongs to the old philosophy of the East. The alchemists—the first chemists—used to consider that there was a good deal of connection between these different metals and the planets. The planets, you know, were named after many of the gods of antiquity; in fact they were worshipped, and were supposed to influence the doings of men in various ways. Astrology is mixed up with this subject; and the ancients considered that lead was connected with Saturn, and that silver was connected with the moon or Diana; tin with Jupiter; gold with the Sun, and Mercury with what was then called quicksilver. It is a metal like silver in appearance, only it moves about as though alive. Venus was supposed to be connected with copper, and iron with Mars. I think I have run through the seven. These names still stick occasionally to the metals, and when we speak of the lead tree we call it still the tree of Saturn. Saturn was considered to be very dull and dark. In fact, Saturn, in the old Indian mythology, meant the sun when under the earth, or the sun at mid-winter, such as the period we have just passed; and Jupiter, in that mythology, was the clear bright sky or the sun in his triumph. And so Saturn was originally not a planet, but the sun when obscured—the sun when dark and dull as at mid-winter. The astrologers imagined that that which was Saturnine—that which belonged to Saturn—was always dull, and heavy, and lead like, and that which belonged to Jupiter was bright. It was the bright metal tin that they called by the name of Jupiter. The idea remains in our language in the two terms "saturnine" and "jovial," because we speak of a man as being saturnine when he is dull and leaden, and we speak of his being jovial when he is bright and sunny.

While I have been giving you this little astro logical episode the gas has been collecting to some extent—hydrogen gas. We will let it go on a little longer before trying its properties. In the meantime I will proceed with the more scientific part of my discourse.

The decomposition which takes place in the silver tree, in this electrotype apparatus, and in all these various cells which I have brought before you of one kind and another—for there is decomposition taking place in all these cases—is what we call electrolysis. Any of you that are Greek scholars will know that this term comes from words signifying loosening or tearing asunder by means of electricity. I have called it "primary electrolysis" when it takes place in the cell, and no galvanic action can take place at all without this primary electrolysis—the splitting up of something or other. Well, supposing we have that action once started, we find that if we were to take any part of the couple, and try what is going on anywhere, whether in the zinc plate or in the copper, or in the wire, we should find that it would be quite possible to make a similar chemical decomposition anywhere throughout the course of the metals. Now that is what we call "secondary electrolysis." It is produced by the first electrolysis, but it is carried on outside the cell.

I will now show you the decomposition of water, and of some other things in that way. You know that water is a compound of two substances—oxygen and hydrogen. This was discovered before voltaic batteries were known, and it was finally proved by Cavendish in an apparatus like this. He put into it hydrogen gas and oxygen gas, and found that by causing a spark to go through the gases, they combined together and produced nothing but water. He discovered also that there must be two measures of hydrogen to one of oxygen, in order to produce water without any residual gas. I will just show you a little of this gas called oxygen. The hydrogen you have already seen. You know that hydrogen burns if you put a light to it, but it will quench the light if you put the light into it. Now this oxygen will not burn, but it will support the combustion of other things. Here is some oxygen gas, and I will just make this piece of charcoal red hot, and put it into the oxygen. [A small piece of incandescent charcoal was accordingly introduced into a jar of oxygen, the result being the rapid burning of the charcoal with brilliant coruscations.] There it goes. If I had taken other things they would also have burnt with (I was going to say) equal brilliancy and beauty, but that would be saying too much; for I have chosen charcoal because it gives you these beautiful scintillations. If any of you want to try it, choose a piece of charcoal made from the bark rather than the wood of the tree, for that scintillates the best.

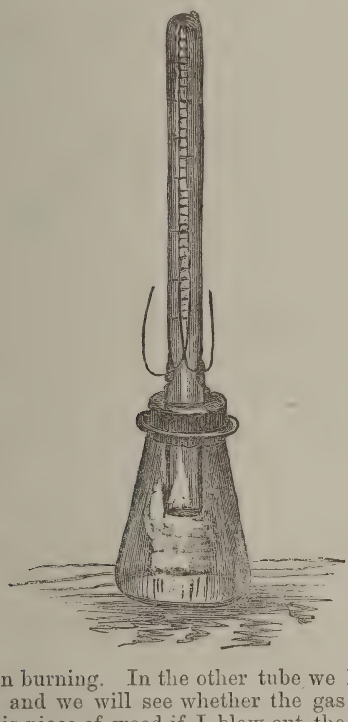
I will now take water, and decompose it by means of a battery. The cells are out of sight, but here are the wires. This water has been coloured in order that you may see it the better. It is pure water with the exception of a little colouring matter. I take these two wires of the battery and join them. They will communicate with these platinum plates which are in the vessel of water. There is no mystery about these platinum plates or "poles," as was once thought; they are just the means by which the power goes into the water. At one of these platinum plates hydrogen gas is being given off, and at the other platinum plate oxygen is being given off. We shall allow that process to go on for some little time. I use platinum, not because there is any particular virtue in that metal; but if I had employed zinc plates the oxygen would have gone to the zinc and made oxide of zinc, and we should never have been able to obtain the oxygen gas in a separate form.

While that is going on, however, I will show you another indication that hydrogen does produce water when combined with oxygen. We will burn this gas as, you remember, we did in the first lecture. Then, if we hold over the flame any cold glass vessel like this, you will see at once that the vessel becomes damped with the water which is being formed by the burning hydrogen, and which condenses on the cold glass. [A jet of hydrogen was then ignited under an inverted glass vessel, upon the sides of which moisture was deposited.] This water has been formed by means of the hydrogen of the flame combining with the oxygen of the air.

Now there is a rapid action going on in the apparatus in which the water is being decomposed by the battery. The bubbles of gas are rising quickly. You see that these two kinds of air are being produced out of the water which is being decomposed, and you remember the properties of these two gases. The hydrogen burns as you see it here, and oxygen, as you saw just now, does not burn itself, but is capable of setting various substances into very violent combustion when they are ignited and brought into it.

Let me call your attention to a remarkable thing that is happening. We had some colouring matter put into the water that is being decomposed, and you will see that in one of the tubes it is entirely bleached. That is not because of the oxygen, but because some ozone has been formed during the process. That ozone has had the effect of destroying the colouring matter. [The hydrogen resulting from the decomposition of the water, and collected in a separate tube, was liberated by means of a stopcock, a lighted taper being applied as the gas issued from the jet.] We have there the

Fig. 4.



hydrogen burning. In the other tube we have the oxygen, and we will see whether the gas will relight this piece of wood if I blow out the flame so as to leave the end of the stick red. [The oxygen was allowed to issue from the jet and impinge upon the incandescent stick. The stick immediately burst into a brilliant flame.] I will now partly blow it out again. You see the oxygen ignites it again. [This experiment was repeated three or four times consecutively.]

Now, supposing that instead of our decomposing water in this way, we decompose it in a vessel in which the gases can be collected together. Here are two platinum plates which rise up into this glass vessel filled with water; the wires of the battery will be attached, and we shall find that the gases will form rapidly when the current is passing. There go the gases; and now we have these gases mixed together, and we will collect them in soapy water, and make bubbles with them. We know that in these bubbles we shall have mixed together the hydrogen which burns, and the oxygen which helps it to burn. [A light was applied to the bubbles of mixed gases, and they exploded with a loud report.]

Well then, I think, we want no further convincing that this galvanic or voltaic power is capable of splitting asunder water into these two gases. Now this fact was taken advantage of by Professor Faraday as the measure for the amount of this power, and he contrived this apparatus which I have been employing. It is called a voltameter (Fig. 4). It is used for the decomposition of water, and we can measure the amount of the mixed gases which are given off, in a certain period, by any current that we wish to estimate. This apparatus which I hold in my hand was, I believe, the first voltameter that Faraday made. It is one roughly constructed by himself, and you see it is made of two little vessels which are used to hold the water; there is a cork fitted into the wider vessel, and it is bored so as to admit of the passage of the narrower tube. And then he has, I suppose with his own hand, caused two wires to pass through this tube, by melting the glass and poking the wires through. He then joined the wires with the battery, and having filled the whole thing with water, he was able to decompose the water, and collect the gases in the upper part of the tube, which has been roughly graduated into so many measures. They look like inches divided into tenths. This is Faraday's own original voltameter; but it has since been, of course, modified in a vast variety of ways.

(To be continued).

THE ROYAL INSTITUTION.

Notes of a Course of Seven Lectures on Electricity.
By Professor Tyndall, LL.D. F.R.S.

February—March, 1875.

Experiments in Lecture 1.

(1.) Place an egg in an egg-cup, balance a lath upon the egg; amber rubbed with the hand attracts the lath. The amber ought to be warm, and the hand dry: if the hand fails, a rub on the coat sleeve will render amber attractive.

(2.) Warm rock-crystal, or warm glass, rubbed with dry hand, also attracts lath. Gutta-percha and ebonite drawn through the hand do the same. A single stroke of a silk handkerchief considerably augments attractive force. This illustrates the influence of the rubber noticed by Newton.

(3.) Ebonite comb passed through the hair powerfully attracts the lath; comb supported by egg is in its turn attracted by lath. This is Boyle's experiment.

(4.) Ball of sulphur mounted so as to be caused to rotate rapidly, with dry hand placed against it, emits light in the dark. This is Otto von Guericke's experiment. A tall glass jar rubbed with silk smeared with amalgam yields vivid streams of "electric fire," which are seen much farther than the light from the sulphur. In all cases where he

development of sparks and crackling is the object, the glass tube and rubber ought to be not only warm, but *hot.*

(5.) Attraction of water and of oil by rubbed amber. An eminence forms under the excited amber, and the crest of the eminence is finally discharged against the attracting body. A strongly excited glass rod brought near the oil (contained in a very small watch-glass quite filled with the oil) raises several eminences, each of which discharges a shower of drops against the rod. This, in an intensified form, is the experiment of the Florentine Academicians.

(6.) Exhausted glass tubes, well warmed and dried, are filled, when rubbed with silk, with diffuse light. When the tubes contain uranium glass, or any other fluorescent body, the light is intensified.

(7.) Mercury in an exhausted tube, shaken to and fro, produces light, which is also intensified by the presence of uranium glass. These are the effects observed by Picard, Bernoulli, Hauksbee, and others.

(8.) Cork protruding from glass tube; penholder, or fir stick some feet in length, stuck into cork, attracts the balanced lath when the glass tube is excited.

(9.) The *approach* of the excited glass tube suffices to develop attractive power at a distance. Support long lath by warm glass tumbler; place fragments of paper, or gold leaf, under one end of lath, and bring excited tube near the other end; the two ends may be many feet apart; the light bodies are attracted.

(10.) A small plate of metal or of wood resting on a glass support—a warm tumbler would answer —is connected with one end of a wire 100 feet long, supported by loops of silk; the other end of the wire is coiled round the end of a warm and dry glass tube. Over the plate of metal or wood rests the short arm of an index, formed of a straw delicately poised. When the glass tube is excited by rubbing, the "virtue" is transmitted through the wire, and communicated to the plate; the end of the index is drawn down, its arrow-head moving upwards, through a foot or more, in consequence.

(11.) When the wire is supported by loops of [illegible] the effect is not obtained. When supported by loops of humid packthread the effect is not obtained; when, instead of the 100-foot wire we employ 100 feet of silk string, the electricity does not pass. But the silk string, when wetted, freely transmits the power. These are the experiments which led Stephen Gray to the discovery of conduction and insulation.

(12.) Support board by stout silk strings. A man stretched upon the board presents his forehead to one end of our straw index. On bringing excited tube near the man's feet his head attracts the short lever of the index, the arrow-head of which moves accordingly. If the index comes sufficiently near the forehead a spark passes between both. This experiment unites those of Stephen Gray and Du Fay.

(13.) Silver leaf let loose in the air plunges towards an excited glass tube, halts before it reaches it, and retreats. It may then be chased by the tube through the air. While thus repelled by the glass, it is strongly attracted by rubbed ebonite or gutta-percha.

(14.) A glass tube, indented at its centre, and supported on a point like a magnetic needle, is, prior to being rubbed, attracted by the excited glass tube; after being rubbed it is strongly repelled. In this condition it is strongly attracted by a rubbed resinous body. A rubbed ebonite comb, paper-cutter, or ruler, properly suspended or supported, is repelled by a second piece of ebonite similarly rubbed. It is attracted by rubbed glass. Speaking generally, the rubbed vitreous body repels the rubbed vitreous body; the rubbed resinous body repels the rubbed resinous body; while the one class when rubbed attracts the other class. This is the fundamental law of electric action established by Du Fay. It is usually expressed by saying that like electricities repel, and unlike electricities attract each other.

NOTES OF LECTURE II. *February* 11, 1875.

1. For a long period bodies were divided into *electrics* and *non-electrics*, the former of which were held to be capable of electrification, the latter not. It is now time to say that the distinction between electrics and non-electrics is really a distinction between insulators and conductors. The conductors being held in the hand, and rubbed, the excited electricity immediately escaped, while it was retained upon the surfaces of insulators. When properly insulated the most perfect conductor can be electrified by friction.

2. The sulphur sphere of Otto von Guericke was, as already stated, the first form of the electric machine. For this Hauksbee and Winckler substituted globes of glass; Boze of Wittenberg (1741) added the prime conductor, which was first a tin tube supported on resin, or by strings of silk. Gordon, of Erfurth, soon afterwards substituted a glass cylinder for the globe. The cylinder was sometimes vertical, sometimes horizontal. He so intensified his sparks as to kill small birds with them. In 1760 the plate-machine now in use was introduced by Planta.

3. Various attempts had been vainly made by Nollet and others to ignite inflammable substances by the electric spark. This was first effected by Ludolf, on the first opening of the Academy of Sciences at Berlin, in 1744. With a spark from the sword of one of the court cavaliers present on the occasion he ignited sulphuric ether.

4. Grummert, a Pole, made various experiments on the luminous discharge through a vacuum. This we have already illustrated; but it is interesting to note that Grummert proposed to illuminate by this light mines in which ordinary flames cannot be employed, a proposal which has been revived with reference to the vacuum tubes of our day. Krüger found that the spark possessed a bleaching power, doubtless through the ozone generated, which was then unknown.

5. Dutour and Waitz, in 1745, and Dr. Watson about the same time, made further experiments on the destruction of electricity by flame. A flame, connected with the earth, instantly discharges an electrified conductor; glowing embers and pointed bodies do so also, but in a less degree.

6. Dr. Watson also made numerous experiments on the ignition of bodies by the electric spark. He fired gunpowder, discharged guns, and, causing a spoon containing ether to be held by an electrified person, he ignited it by presenting to it the finger of an unelectrified person. He noticed that the

spark varied in colour as the substances between which it passed varied.

EXPERIMENTS IN LECTURE II.

As in Lecture I. we shall employ, in part, a lath balanced on an egg as our test of attraction.

(1.) A ball of brass, of wood coated with tinfoil, a lead bullet, or an apple, held in the hand and struck briskly with silk, flannel, or a fox's brush, fails to attract the balanced lath. Suspended by a string of silk and similarly struck, the attraction is decided.

(2.) A brass tube held in the hand and struck with the fox's brush shows no attractive power; but when a stick of sealing-wax, ebonite, or gutta-percha is introduced into the tube as a handle, the striking of the tube at once developes attractive power.

(3.) The mere touching of the brass tube by the finger causes the power to disappear.

(4.) Removing the handle and exciting *it* by the friction of flannel, silk, or fur, it attracts lath. But it may be repeatedly touched, and still retain its power of attraction. In the case of the conductor the touching of any point causes it to yield up the whole of its electricity; in the case of the insulator only the spot touched yields up its electricity.

(5.) The human body was ranked among the non-electrics. I stand on the floor and permit an assistant to strike me briskly with the fox's brush. I present my knuckle to the balanced lath, but there is no attraction. Placing a board on four warm glass tumblers I stand on it: a few strokes of the fur suffice to develop a strong attractive power. Presenting my knuckle to that of my assistant, who stands on the ground, a spark passes between us. If I stand upon a cake of resin, of ebonite, or upon a sheet of good india-rubber, the effect is the same.

This action is considerably augmented by throwing a mackintosh over the shoulders and having it struck.

(6.) Thus non-electrics, like electrics, can be excited; the condition of doing so being that an insulator shall be interposed between the non-electric and the earth.

(7.) A sheet of foolscap, well warmed, so as to expel the humidity which paper always imbibes from the air, placed on a hot board, becomes strongly excited when india-rubber is passed over it. It resists removal from the board, and when torn away attracts the balanced lath from a considerable distance. If brought near a wall it will move up to it and cling to it.

(8.) Two strips cut from the excited foolscap, as it lies upon the hot board, are placed one upon the other. When laid hold of at one end and separated from the board, they violently repel each other. This is a consequence of the fundamental law already illustrated.

(9.) The gold leaf electroscope acts in the same way. When electricity is communicated to the metal top of the instrument it diffuses itself immediately over the gold leaves, which then repel each other like the strips of paper. The lightness of the gold leaf enables it to respond to very feeble charges of electricity.

(10.) A simple and effective electroscope for teaching purposes (devised by Mr. Cottrell) may be formed of a straw about 18 inches or 2 feet long. Within two or three inches of the blunt end of the straw, a second or thinner straw about an inch long is passed transversely through the first. Half a stick of sealing-wax is stuck against an upright support, and a sewing-needle is fixed in the sealing-wax. This needle is introduced into the transverse inch of straw and serves as a horizontal pivot. The blunt end of the straw carries a little weight, just sufficient to keep the straw vertical. Thus arranged the straw is very mobile. It is attracted by any electrified body; but on touching the body it is charged and immediately repelled, the sealing-wax preventing the escape of the electricity. The straw index moves over a graduated arc.

(11.) The electrical machine, beginning with its first form as a sphere of sulphur, then as a globe of glass, then as a cylinder vertical and horizontal, then as a plate of glass, and finally as a plate of ebonite, was illustrated by examples.

(12.) Standing on an insulating stool and placing one hand on its prime conductor, the ebonite machine was worked: the knuckle being brought down upon a spoon containing sulphuric ether, a spark passed and the ether was ignited. The spoon was next held in the hand of the excited person, and ignited by a spark from the knuckle of another standing on the earth. These are the experiments of Ludolf and Bishop Watson.

(13.) The presentation of the point of a penknife to the prime conductor at a distance of three inches prevented almost wholly the charging of the conductor.

(14.) Mounting a pointed rod upon the prime conductor, a strong cool wind issued from the point when the machine was worked. This wind was competent to blow aside a sheet of paper. When the point was turned downwards the "electric wind" forcibly depressed the flame of a candle placed underneath the point. Franklin, as we shall afterwards learn, turned these experiments to important account.

(15.) A cross was formed of four wires, the pointed ends of which were all bent in the same direction so as to form a right angle. A brass axis passing through the intersection of the arms of the cross was permitted to rest upon two parallel wires supported by glass rods. One of the parallel rods being connected with the conductor of a machine, the whole system was electrified. From every point issued the "electric wind," the reaction of which caused the cross to rotate and roll from one end to the other of the parallel bars. This is a form of the "electric mill," devised by Hamilton.

(16.) The electric wind from a glowing body was shown by the sweeping away several times in succession of the black smoke from a wax taper after the flame was extinguished. The wick of the taper was here connected by a wire with the electrical machine. This and the last experiment were made after the manner of Canton, who employed in his observations the shadows of electrified threads, instead of the threads themselves.

(17.) The quickening of the flow of water by electricity was shown by suspending a metal bucket from an insulated arm, and connecting it with the electric machine. Through a small orifice in the bottom of the bucket water dropped slowly; when the machine was worked the drops quickened to a continuous stream.

NOTE REGARDING ACTION OF CURRENTS ON MAGNETS.

By Prof. W. E. AYRTON, Japan.

In the majority of treatises on Natural Philosophy rules are given to connect the way in which a magnet will be deflected with the direction of the current acting on it. These rules either have reference to an imaginary man swimming along the wire with the current, or to imaginary corkscrews. Both sets of rules are—as far as my experience with students has shown—most successful in producing confusion. In addition, in countries like Japan, where corks have been but recently introduced, and, therefore, where corkscrews are comparatively unknown, it is obvious that any rules depending on a familiarity with these implements must be far from being lucid.

The following, which I have found students easily remember and correctly apply in any case, are therefore, I think, worthy of publication in your Journal:—

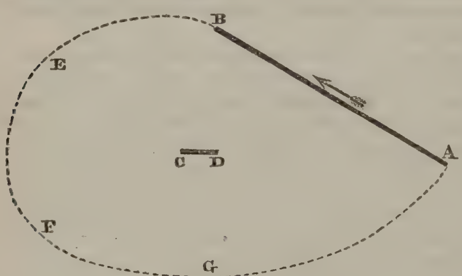
Let rotation opposite to that of the hands of a watch be called (as it always is in trigonometry and mathematics generally) *positive rotation*, and the reverse *negative*.

Let the "north-seeking end" of a magnet (English "North Pole;" French, "Le Pôle Austral") be called, as Faraday termed it to avoid confusion, the *marked end*, and the opposite end the *unmarked end*.

Let the observer look at a coil of wire along the axis of the coil, that is, along a line perpendicular to the plane of the coil, then—

I. If the direction of rotation of a current in a coil of wire encircling a magnet be positive, the marked end of the magnet will come towards the observer; or if negative, the unmarked end.

II. If a current pass along any wire (A B) placed anywhere near a magnet (C D), then it may be



regarded as part of a complete circuit, A B E F G, encircling the magnet; consequently, if the current flow from A to B, the direction of rotation of the current is positive,—therefore the marked end of the magnet will come towards the observer, and *vice versa*.

Electro-Magnets.

III. If the direction of rotation of a current round a piece of iron be positive, the end of the iron nearest the observer will become a marked end, and consequently the other end of the piece of ron an unmarked end.

These rules, and especially the latter one, have the advantage of not referring (as the ordinary rules do) to which end of the coil the current enters; all the observer has to consider is simply—*Is the direction of rotation of the current positive or negative?*

If *memoria technica* be desired, we have—

*N*egative rotation of current.	u*N*marked end comes to observer always.

Notes.

It is not often that a telegraph ship has to pass the ordeal of a military bombardment. This has happened to the *Caroline*, while laying a short cable on the coast of Spain. The Carlists have driven her off her work, and she is now engaged in repairing the Lizard cable.

The well-worked and well-managed Indo-European line, which has on its Board names so well known in telegraphic circles as W. H. Barlow, C. W. Siemens, and H. Weaver, has obtained—in the year 1874—an increase of 45 per cent on its receipts, they having risen from £54,897 in 1873 to £79,466. The Government have agreed to reduce the rent payable by the Company for the use of the land and cable wire from £12,000 to £6700 per annum.

The Telegraph Construction Company have netted upon their last year's contracts a profit of no less than £371,381. They had constructed, to the end of the year 1873, 37,211 miles of cable, and they have added to this vast mileage about 5973 miles, laid in 1874.

The Anglo-American Company have resolved to reduce their tariff to America one-half on May 1st.

The tallest and largest telegraph pole in New York, perhaps in the world, was raised in Fulton Street, near St. Paul's Church, on January 17th. It is to be used to support the distributing wires that will extend from the new building of the Western Union Telegraph Company at Dey Street and Broadway. The pole is 93 feet long and 2 feet in diameter, and reaches high above the neigh-neighbouring buildings. The raising required the labour of a large number of men and two horses, and completely blocked the street for some time, The tree from which the pole was made was of Californian growth.

The *Sydney Hall* has just left Messrs. Siemens's works, North Woolwich, with a cable for the Montevidean and Brazilian Telegraph Company, and she will be shortly followed by the *Ambassador* with the cable manufactured to replace that lost in the *La Plata*.

The *Hooper* has successfully laid the cable between Trinidad and St. Croix, the insulation of which is reported to be superb.

Mr. Stearns is in Paris, busily applying his duplex system to the Hughes printing apparatus, which is the favourite instrument in France—Morse being nowhere. He has been very successful between Paris and Versailles, Rouen and Havre. Mr. Stearns is sure to be successful anywhere, for he certainly is one of the ablest practical electricians of the day. It is very gratifying to see how his success, and that of his countrymen generally, fail to produce the smallest symptom of national jealousy in England. Truly in Telegraphy Anglo-Americans form but one nation.

The following statistics of a "healthy" office, taken from the *Journal of the Telegraph*, are interesting:—

Kansas City, Mo., ten years ago, had a population of about 4000. It has now 40,000. The following is the telegraphic work done therein during the month of December:—

Number of messages handled	30,441
Reports and specials, 106,997 words, reduced to message basis	5,349
Total number of messages	35,790
Number of operators, including chief	7
Daily average messages to each operator	204

Mr. Haskins has suggested and experimented upon the use of condensers as relays, and an interesting paper was read by him to the American Electrical Society on this subject.

Proceedings of Societies.

SOCIETY OF TELEGRAPH ENGINEERS.

INAUGURAL ADDRESS, BY MR. LATIMER CLARK, PRESIDENT. JANUARY 13, 1875.

(Continued from page 47.)

REVERTING to the progress of the telegraph in England, we find Mr. Cooke in 1837 in negotiation with the directors of the London and Birmingham Railway for laying down a telegraph from London to Birmingham, a project which did not, however, arrive at completion. In the following year (1838) Mr. Cooke conducted some extensive experiments at St. Katharine's Docks, in which he exhibited the telegraph in operation through 110 miles of No. 16 covered copper wire. Mr. Brunel at this period took up the matter, and a line of pipes with five wires was laid down on the Great Western Railway from Paddington to Drayton, which was afterwards extended to Slough in 1841. The total cost of this line to Drayton was £3270 6s. The insulation becoming defective, the pipes were removed and sold, and poles and iron wires were erected in their place in 1841, the wire being in the first instance temporarily insulated on quills. In 1840 Mr. George Stephenson adopted it on the Blackwall Railway, which was then worked by a stationary engine and rope. In 1841 Sir Charles Fox ordered a telegraph on the Cowlairs and Glasgow Line. It was then fixed on one of the Midland tunnels, and on the Dublin and Dalkey Atmospheric Railway.

In 1842 Mr. Cooke was in negotiation with the Admiralty in reference to a line from London to Portsmouth; he also published a book termed "Telegraphic Railways on the Single Way." In this year plans for the Norwich and Yarmouth Line were approved by Mr. George Hudson. In 1843 the telegraph was ordered for the Dalkey and Kingstown Atmospheric Railway by Mr. Samuda, and on this line galvanised iron wire was first employed. The Norwich and Yarmouth Railway, a single line, was opened in May 1844; the Northampton and Peterborough Line and the Croydon Line were completed in 1845. These were followed by the South Western Line from London to Gosport, and the South Eastern Line, the first portion executed being the Maidstone Branch.

It appears that the funds necessary for the management of the partnership were provided by Mr. Cooke, and the results were at first by no means encouraging. His account books, which were produced in evidence during an arbitration which took place in 1841, before Marc Isambard Brunel and Professor Daniell, showed that, prior to his connection with Professor Wheatstone in February 1837, he had expended £385 8s. 10d. on his experiments; by the end of 1843 this deficit had increased to £6232 16s. 1d.

The celebrated message which led to the capture of John Tawell, a quaker, who had committed a murder at Slough, was sent on the 1st January, 1845, and it had a powerful influence in arousing public attention to the value and capabilities of the telegraph.

In erecting the Blackwall Railway Mr. Cooke made the acquaintance of Mr. George Stephenson and Mr. George Bidder, and in 1842 Messrs. Cook and Wheatstone inserted a series of advertisements in the *Railway Times* and other papers drawing attention to the merits of their invention. These circumstances eventually led to Mr. Cooke's introduction by Mr. Bidder to Mr. John Lewis Ricardo, M.P., afterwards for many years Chairman of the Electric Telegraph Company, a gentleman by whose energy and enterprise the Company was created and led to a high pitch of prosperity. The first interview took place on the 1st of October, 1845, and so prompt and decisive was their action that on the 17th of that month Mr. Ricardo and Mr. Bidder wrote a joint letter to Mr. Cooke accepting the terms he had proposed.

The Company was registered on the 2nd of September, 1845, and a provisional prospectus was issued shortly afterwards.

The first directors were Mr. J. L. Ricardo, Mr. Sampson Ricardo, Mr. W. F. Cooke, Mr. George Bidder, and Mr. Richard Till. An Act of Parliament was obtained on the 18th June, 1846, and they commenced business, in an imperfect manner, at their first offices at 345, Strand, where they educated their clerks, the system employed being the Cooke and Wheatstone double-needle instrument.

The capital of the Company was privately subscribed by the directors above named, and it would appear that under the arrangements made with the patentees they received about £160,000 for their patents in money or value. This purchase included Mr. Cooke's half-share of the London and Portsmouth Telegraph and the telegraph to Slough. Out of this amount Professor Wheatstone received £30,000 in cash and £3000 for royalties then due, and Mr. Cooke received the remainder. I believe, however, that Mr. Cooke's personal share amounted practically to about £96,000, of which the greater portion was in shares, many of which were subsequently disposed of at a loss.

During 1847 the Electric Telegraph Company erected their central station at the end of Founder's Court, Lothbury, the funds for this handsome building having been provided by Sir Samuel Morton Peto. It was formally opened on the 1st January, 1848, and at this period 1514 miles of telegraph were either erected or in progress.

The business was not an uninterrupted success. On the first day they took about £20, but this amount steadily increased each day.

The large hall was filled up with instruments from top to bottom, each gallery being appropriated to a different division of the country, and having a staff of clerks ready to receive and transmit messages. I believe at that time the cost of a twenty-word message from London to Glasgow or Edinburgh was about 17s. 6d.; to Yarmouth 9s. 6d.; to Ipswich 5s. 6d.; and to Southampton 3s.

It was soon found that they had over-rated the immediate capabilities of the telegraph traffic; they had spent all their capital, and their expenditure greatly exceeded their receipts. It became necessary to effect a great reduction in their expenses, and on the 27th March at one swoop they discharged about four-fifths of their clerks, who were, however, re-engaged as their prospects improved.

The year which followed was one of great commercial disaster consequent on the French Revolution and the abdication of Louis Philippe. By the month of June, 1848, the operations of the Company had resulted in the loss of £3220 8s., and the whole undertaking might have collapsed had not Mr. Ricardo advanced money, and taken upon himself the burden of other shareholders, whose confidence in the Company had ceased. They were at this time receiving about £100 per week for messages, and by December their actual loss had been reduced to 341 0s. 11d.

In January, 1849, they were able for the first time to speak direct without delay from London to Birmingham and Manchester. This was considered a great telegraphic feat.

In the year 1850 their gross revenue from all sources was £43,524 3s. 9d., out of which they made a profit of £10,075 12s. 3d.

In 1851, the year of the Great Exhibition, their gross revenue was £49,866. In 1852, their receipts for messages amounted to £100 per day. In 1860, their revenue had increased to £214,245 7s. 3d., and their profits to £69,711 14s.

The 30th June, 1868, was the day fixed for the transfer of the whole system to the Post Office Department of Her Majesty's Government, but owing to various delays the actual transfer did not take place till the 28th January, 1870.

Their receipts for the thirteen months ending on this date were £425,789 2s., and their profits £202,480 6s. 2d.

On finally winding-up, the Company, in addition to interim dividends (which were limited by their Act to 10 per cent per annum), the shareholders divided among themselves a sum of £2,938,826 9s. received from the Government, and a Trust Fund of £40,721 17s., being equal to a dividend of £292 1s. 3d. per cent upon their capital.

The Electric Telegraph Company was not, however, allowed to pursue its way without opposition. In July, 1850, the British Electric Telegraph Company obtained their Act, their engineer being Mr. Edward Highton, and in the same year the Magnetic Telegraph Company was originated, their engineer being Mr. Charles Bright, and at first they employed the electro-magnetic instrument of Mr. Henley.

These two Companies afterwards amalgamated and became a powerful rival of the Electric Telegraph Company. The United Kingdon Telegraph Company obtained their Act in 1861, their engineer being Mr. Andrews, and they also erected an extensive system of telegraphs, and introduced the Hughes Printing Telegraph.

The Electric Telegraph Company endeavoured to establish a practical monopoly by either opposing or purchasing the inventions of rival patentees. Among these the chemical printing telegraph of Mr. Alexander Bain deserves especial notice. Chemical telegraphs were suggested at an early date, and in 1838 Mr. Edward Davy patented a chemically-marking telegraph of considerable merit, employing calico tapes moistened with iodide of potassium. In December, 1846, Mr. Bain patented his system, and in addition to the use of an iron style resting on paper moistened with a solution of ferrocyanide of potassium, described the important principle of setting up the messages on perforated paper, a system which has done more to increase the capabilities of the telegraph than any other invention.

That invention was exhibited to the Electric Telegraph Company, and while being examined one of the regulating springs broke and allowed the instrument to travel round with uncontrolled speed. To their surprise they found that the whole message was visible, and had been transmitted correctly at the rate of several hundred words per minute, upon which they resolved to purchase the invention without delay. I believe Mr. Bain received £7000 for his patent and for the withdrawal of his opposition to their Bill. They employed the system of printing on chemical paper for some years, until it was eventually supplanted by the Morse inking system. Nothing, however, was done with the punched paper until Sir Charles Wheatstone introduced his very beautiful automatic printing telegraph, which is the most rapid system of telegraphing at present in ordinary use.

The real capabilities of the Bain system remain, however, to be yet developed. The Americans have recently re-introduced it with startling results, and have shown that on ordinary circuits four hundred or five hundred words per minute may be readily transmitted by its means.

When the capabilities of this system become generally known to the public, they will doubtless insist on enjoying the advantages to be derived from it, either in the form of lengthened messages or a lowered tariff. It appears to me, that in order to obtain the full benefits of telegraphic communication any reduction in the cost should be accompanied by the introduction of *express messages*, a species of message bearing the same relation to ordinary messages that passenger trains bear to goods trains. The cost of these messages should be at least five or ten times as great as that of ordinary messages, and they should be subject to the same rules of priority among themselves as now exist, but they should in all cases take precedence of the ordinary heavy traffic. Without some such system much of the celerity to which we are now accustomed will be lost amidst the enormous accumulation of work which must sooner or later fall upon the telegraphic system of this country. The Electric Telegraph is quite capable of transmitting a large portion of the business of the country which is now transacted by letter, and is being so employed more and more every day. If this expansion of traffic be accompanied by facilities for securing rapid transmission for important messages the pecuniary gain to the "Post-office" will be very great, while the benefits afforded to the commerce of the country will be enormous.

(To be continued.)

Post-Office Telegraphs.—Statement showing the total number of messages forwarded from Postal Telegraph Stations in the United Kingdom during the week ended the 13th February, 1875, and during the corresponding week of 1874:—1875, 342,197; 1874, 352,426; decrease in the week of 1875 on that of 1874, 10,229. The large number of telegrams in the corresponding week of last year was due to the general election.—Week ended 20th February, 1875, and corresponding week of 1874:—1875, 347,108; 1874, 326,496; increase in the week of 1875 on that of 1874, 20,612.

Notices of Books.

Introduction to Experimintal Physics, Theoretical and Practical, &c. By Adolf F. Weinhold. London: Longmans, Green, and Co.

This is a most excellent work, and worthy of the great house of Longmans. The author is Professor in the Royal Technical School at Chemnitz, the principal manufacturing town—the Manchester—of Saxony. It is admirably translated and edited by Mr. Benjamin Loewy, and it is introduced by a valuable preface on self-culture and self-tuition in Physics, by Prof. G. C. Foster, F.R.S., of University College, and one of the Vice-Presidents of the Society of Telegraph Engineers. We have so recently urged upon all students of Electricity the necessity of experiment, that it is a matter of great satisfaction to find a work so speedily produced to meet the views propounded. There is no doubt that the only way to impress physical facts upon the mind of students is to make them experiment themselves, and to let them draw their own deductions from their own observations. As Prof. Foster says—"In any sound system of teaching, particulars must come before generalities; for unless a student has clear conceptions of individual phenomena, it is impossible for him to understand their mutual relations, or the general conclusions that are based upon them." Mere reading or listening, or seeing descriptions and experiments, are not enough; the student must experiment and observe for himself not necessarily all the facts of a science, but certainly those illustrating the main elementary principles upon which the science is based. Interest is thus excited, thought is stimulated, reflection exercised. Here is a book which gives the fullest and clearest descriptions of the mode of making the simplest apparatus at the least cost, and the precautions necessary to enable the student himself to make the fundamental experiments in all the Physical Sciences, and in the elementary principles of Statics and Dynamics, on which Natural Philosophy is founded. The expensive ready-made apparatus of the instrument maker is as much as possible discarded. With very few exceptions, any one with a taste for mechanical occupations and a fair amount of handiness could—with patience, and by carefully following the directions given—make all the apparatus referred to in the book. Prof. Weinhold says himself:—

"The most indispensable qualification for one who wants to make real use of this book is *perseverance*. Skilfulness in practical operations—such as the working of metals or of glass, or in actually making experiments—is only to be obtained through practice; and since it is impossible for even the most carefully written instructions to provide against every mistake that a student can possibly make, personal experience must every now and then be the real teacher. Whenever anything does not succeed the first time, the student should try it again; but he should not try thoughtlessly, on the mere chance of better luck next time; he should endeavour, by careful consideration, to find out the cause of his ill success. The completion of a piece of apparatus, or the success of an experiment, well repays the trouble spent upon it; the skill that has been gained in the process never turns out useless afterwards, and occasions arise in which even those whose chief occupations lie in quite other directions are able to recognise its value."

The book deals with the general properties of matter, Mechanics, and all the other "ics," including Acoustics and Optics, Electricity, Magnetism, and Heat. The decimal (metrical) measurement is used throughout. That portion relating to the various motions of matter, especially the vibratory, is admirable. Names are avoided and history discarded as much as possible, and thus the author steers clear of the Scylla and Charybdis of national jealousy and individual vexation. The illustrations are very good, and the excellent plan is adopted of giving the scale to which every diagram is drawn. The electrical portion is perhaps a little behind the age; but this is perhaps owing to the fact that the age is rather too much in advance of the philosopher, for certainly practice in this science has shot far ahead of theory. Nevertheless, no student in any physical department should be without this much-needed book, not so much because it teaches him all that is worth knowing in Experimental Physics, but that it shows him the proper way to acquire a knowledge of that which is known by self-tuition and self-help.

Electrical Science in English and Foreign Journals.

Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences. Vol. lxxx., No. 4. January 25, 1875.

On the Effect produced by the Application of Armatures to Perfect Magnets.—J. Jamin.—An intricate article, replete with mathematical investigations, best studied in the original. The conclusions arrived at are—(1.) If a single armature be placed to the north pole of a magnet it does not in any way modify the magnetic condition of the unarmatured south portion of the magnet. If now we consider the effect of applying an armature to the magnet's south extremity, we find that the magnetism is lost, but is acquired by the armature: *this new distribution is in no way modified if we pluck off and attach the armature on the north extremity;* hence, regard being had to these armatures, there is an absolute independence between the two halves of the magnet. (2.) The application of an armature to one of the ends of a magnet provokes in it a new distribution, *but neither diminishes nor augments its previous quantity.* This fact does not appear directly from experiment, since the armature seems to gain more than the magnet loses. The cause of this difference is the different magnetic conductibility of the steel magnet and of the iron proof plane with which the strength of the magnet is estimated. The process of obtaining this estimate consists in dividing the surface of the magnet into small squares, and the sum of the square root of the wrenching forces necessary to detach a "proof plane" from the centre of each of these squares measures the total magnetism.

A note by E. Ducretet relative to the *Electro-Chemical Resistance offered by Aluminium when used as a Positive Electrode in a Voltameter.* He says—"A water-voltameter (containing acidulated water, platinum, and aluminium plates) in communication with the poles of a battery disengages hydrogen at the negative electrode, aluminium. If the current is reversed the water is no longer decomposed, and the current becomes excessively feeble. This phenomenon is produced instantly, however rapidly the currents are changed." M. Ducretet constructs, upon this principle, a *liquid rheotome*, permitting the passage of currents in one determined direction only, and points out the applications of such an apparatus to telegraph lines, electric bells, the explosion of mines, &c.

Les Mondes. Vol. xxxvi., No. 2. January 14, 1875.

Contains a long biography, by M. Dumas, of the eminent electrician M. Auguste De la Rive, and no other articles in any way touching upon electrical and telegraphic sciences.

No. 4. January 28, 1875.

Electric Light.—It appears that at the present time experiments are being carried on in Paris, for the

Russian Government, respecting the projection of electric light to great distances. The light is placed in a kind of box made from a large iron tube, 1·20 metres in diameter and 0·90 metre long. The front opening contains a lens, 1·15 metres diameter, which completely closes it; the other end is closed by a copper lid supporting a reflector. In this lid two peep-holes—similar to those in the stereoscope—are arranged, by which to examine the luminous focus. The range of this apparatus is more than 15 kilos. (nearly 10 miles), and at that distance objects included in the luminous cone are tolerably lighted up. The distance of the carbon-points is regulated by clockwork.

No. 5. February 4, 1875.

Camacho's Concentric Tube Electro-Magnet.—Already described in our columns (vol. ii., p. 342), to which we refer our readers.

New Electric Light (discovered by M. Ladygene, and of which particulars were detailed in vol. ii., p. 202, of this Journal), has been deemed of such importance by the Russian Academy of Science that they have awarded him the Lomonossow Prize.

Annalen der Physik und Chemie, von J. C. Poggendorff. 1874. No. 10.

On Electric Currents produced by the Non-simultaneous Immersion of Two Copper Electrodes in Various Liquids.—G. Quincke.

Appendix:—*On the Presumed Relations between Capillary and Electric Phenomena.*

Preliminary Experiments with a Magnetised Copper Wire.—B. Stewart and A. Schuster. See Tel. Journ., vol. ii., p. 193.

On the Question of the Duration of Propagation of Magnetic "Actio in Distans."—H. Herweg.

On a Modification of the Electro-Magnetic Rotation Experiment.—H. Herweg.

Comparison between Electric Machines. M. Mascart.

Measurement of the Electro-Motive Power of Voltaic Batteries in Absolute Units.—A. Crova. See Tel. Journ., vol. ii., pp. 204, 277.

Induction Action of Magnetic Rods of Unequally-Hard Steel.—L. Külp.

No. 11.

Thermo-Electric Studies.—E. Budde.

Checking of the Torsion Vibrations of Wires.—H. Streintz.

On Galvanic Resistance to Conduction.—H. Herweg.

No. 12.

Experimental Investigation on the Behaviour of Non-Conducting Bodies under the Influence of Electric Forces.—L. Boltzmann.

On the Play of the Electrophorus Machine, and on Double Influence.—P. Riess.

Criticism in Electro-Dynamics.—H. Helmholtz.

Conduction of a Current by Metallic Sulphides.—F. Braun.

Remarks concerning the Theory of Electricity.—R. Edlund.

Remarks on an Electro-Dynamic Experiment.—F. Zöllner. F. Lippich.

Bunsen's Carbon-Zinc Battery made Self-Evacuative.—A. Gawalowski.

Revista de Telégrafos. No. 24, Anno xiv. December 15, 1874.

The "official section" contains a decree authorising the construction of a submarine telegraph connecting San Sebastian with Fuenterrabia.

The members of the telegraphic staff of Cuba and Puerto-Rico have addressed a memorial to the Minister for Transmarine Affairs, complaining that vacancies arising in those islands are supplied by telegraphists from Spain, and that thus their prospects for promotion are practically extinguished.

The non-official portion contains a paper on the method of testing the electric condition of submarine cables, extracted from the work of A. L. Ternant on Submarine Telegraphy, with notes by T. Picco.

The Minister of War is about to employ the nocturnal optical telegraph of D. Enrique Bonet in the campaign in the north.

The Government of the United States of Colombia, which undertook in 1864 the construction of its telegraphic system, possesses now 1600 kilos. of lines in service, uniting the capital with the principal cities of the north of the Republic, and with the port of Buenaventura on the Pacific. At that port the above-mentioned net-work of lines are to be connected with the submarine cables of the west coast of South America to Peru and Chili, which, ascending northwards as far as Panama, will meet there the system of communications established between America and Europe.

The steamer *Vandalia*, of Hamburg, caught with its anchor the cable from Jamaica to Colon, on the 4th of November last, causing a damage of small importance, which was quickly repaired, without the service of this important line having suffered any serious interruption.

The *Fanfulla*, speaking of the meeting held for erecting at Bologna a monument for the illustrious physicist L. Galvani, says that the designs given in were twenty-three in number, the jury deciding in favour of the young Roman sculptor Cencetti. The artist has selected the culminating point of the scientific life of Galvani, in which the immortal Bolognese is attentively watching the electric phenomena manifested in the movements of the frog. The expression of the face and of the whole body reveal the anxiety of the man of science and the emotion produced by a great discovery.

Journal Telegraphique. Vol. ii., No. 36. December, 1874.

Continuation of *Schwendler's General Theory of Duplex Telegraphy*, of which we have already given the author's principal conclusions.

New Lightning Protector for Telegraph Lines (Lemasson System).—Among the different lightning protectors invented to protect telegraph lines, one of those most used is formed of two plates furnished with points and insulated from each other, one plate being traversed by the line current, and the other placed in communication with the earth. So long as atmospheric electricity is moderate the current goes through the first plate only, but when excessive it runs to earth through the points and the second plate. M. Lemasson proposes to render such a lightning protector of greater efficiency. He places a tube inside a conducting mass, provided with 100 transverse striates, and in immediate contact with earth. A cylinder communicating with the line occupies the centre of the tube, but does not touch it, and is provided with 40 longitudinal striates. By reason of the different direction of the striates, 4000 crossings are obtained,—uniformly distant ½ a millimetre from each other,—and these crossings may be regarded as so many points. Hence, although measuring only 1 decimetre in length by 4 centimetres wide and broad, M. Lemasson's arrangement, though much smaller, is more efficient than that in ordinary use. An important addition to the apparatus is the insertion of a pipe (furnished with a stop-cock) to the air-space between the "tube" and the "conducting mass," so as to rarefy the air, and thereby diminish the resistance offered to the discharge of excessive atmospheric electricity.

THE TELEGRAPHIC JOURNAL.

Vol. III.—No. 51.

TELEGRAPHIC COMPETITION.

The sounds of telegraphic warfare that are wafted across the Atlantic appear to us, on this side, like history repeating itself. We have seen the same phases of determined opposition, we have suffered from the same causes, we have surmounted the same troubles, but we have landed on safe shores, and can survey with untroubled minds the serried ranks of the opposing forces. Competition is a thing of the past in inland telegraphy; it is left to our Submarine Commercial Companies.

It is one of the misfortunes of success to excite envy and rivalry. No one can watch profit without desiring to share in it. The early losses and disasters of the first telegraphists in this country were no sooner recovered, and the enterprising speculators showed their heads above water and began to profit from their speculations, than rivals sprouted up to rob them of their rewards by underbidding them to the public. *Delirant reges plectuntur achivi;* but in this case the people had the best of it, for competition meant lower tariffs, and lower tariffs meant the public benefit. The Electric begat the British, the British begat the Magnetic, and these begat the United Kingdom, *et hoc genus omne*, until a wise and paternal Government stepped in, swallowed the whole, and begat the uniform shilling. Our American cousins are familiar with telegraphic enterprises and telegraphic competition, but now the combatants are practically reduced to two powerful companies—the Western Union and the Atlantic and Pacific. The latter are the assailants, and have commenced the battle by reducing the tariff from 40 cents to 25 cents for ten words, between New York and Washington, and other places. The enormous area of the United States precludes a uniform tariff: hence they have a 25 cents, a 40 cents, and a 60 cents tariff, with 2, 3, and 4 cents for each additional word. The Western Union have followed suit, and to the same extent. Both companies are relying upon duplex, quadruplex, and automatic system for despatch and the means to accommodate the extra business anticipated. Both parties are said to be bitterly hostile, and bent on performing that operation familiarly known to us in the story of the Kilkenny cats. The longest purse will perhaps win. The Western Union Company have just secured a million from the London market, which will materially aid their operations. Congress is also very active in discussing telegraphic projects in connection with the Government, and it will probably end—as it has in Great Britain—in the establishment of a national telegraph. Of course the telegraphic fraternity and press in America are opposed to this movement; so were we in England, but we were beaten, and we are not sorry for it. We have cheap Telegraphy; we have wonderful facilities everywhere, especially to the press; we have great despatch in the transit of messages; and we have a decided improvement, in every shape and form, in the transaction of telegraphic business. But, say the opponents to Government absorption in America, it does not pay—no national telegraph pays. True it does not pay as a commercial speculation, earning handsome dividends; but who wants it to pay as such? Again, they say estimates have been exceeded; but they forget that the business has also exceeded the most sanguine estimates. If all the claims that remain outstanding against the British Government—preposterous as they are—be paid in full, what does it amount to? The nation will have paid about five shillings per head for their telegraphs,—and who is there who has not saved this in the economy effected, the convenience acquired, and the despatch assured by the new system? There is not a reader of a penny paper who is not benefitted by the change, and the inhabitants of sparsely populated districts would never have been brought within the range of civilisation but for its means. Moreover, there is the feeling in the public mind that the telegraphs are its own, and it has a control over their working,—nor does it fail to let this control be felt, either through the press or in the House of Commons, when anything goes wrong. The national system of telegraphs in England—like the Post-Office, with which it is allied—is the most closely supervised department in the world, for the eyes of its master—the public—are everywhere. It is therefore bound to work well, and it unquestionably does so. American telegraphy will not be satisfactory until it is in the same category.

THE VOLTAIC BATTERY.

A Course of Six Lectures,

By Dr. JOHN HALL GLADSTONE, F.R.S.,

Fullerian Professor of Chemistry, Royal Institution.

Delivered at the Royal Institution of Great Britain.—Christmas, 1874-5.

(Continued from page 53.)

I should like to show you now the decomposition of other substances. We may take the wires a long way from the decomposing cells. I do not myself know where the batteries are which are connected with these wires, but they are a good way from this table at any rate. We can bring the power up into

this room, and here we can produce decompositions just similar to those which I showed you taking place at the last lecture. We will have a representation upon the screen of some decompositions of metallic salts. We might go, if we pleased, through the whole range that we took at the last lecture, and show the reduction of silver, and copper, and tin, and bismuth, and gold, and any other salts; but I think we will confine ourselves to three metals, We will take lead first of all, and we will see how it will behave. We have a small cell with flat sides, and we have the two poles of the battery—the ends of the two wires—in the solution. You see them sticking up. Directly the galvanic power is put on we shall see that the lead salt is decomposed, and we shall get crystals similar to those which we had before. There are the crystals of lead growing very large, as you saw them in the lead tree. You will understand that they only appear on one of these poles. The lead, which is the positive element, goes towards the negative wire, and there the crystals stretch across. Here we have one of these leaves put sideways towards us, making its way very rapidly. Here are others turning in various directions, and, at the same time, seeking the positive pole. If they came actually to touch the two poles, then the currents would go through the metals themselves, and we should have no more decomposition; but we ought to be able to reverse the current, and let it go the other way through the liquid. We ought then to have the metal appearing on the other pole. Ought we not? Let us see whether it does so. Now the current is reversed, and we ought to see the growth of crystals from the opposite pole, and at the same time the bubbles appearing where the crystals had been before. [After a few seconds the action became manifest.] Look at this strange sort of spiderlegs appearing. Here is a bunch of very respectable crystals at the bottom, but these long thin things twist about above. This one is going in a very straight methodical business-like way right across, and will soon reach to the other side. Now we have the oxygen appearing on the other pole, but we have no time to watch it any longer.

Now let us have tin. You recollect the tin—how it was built up, having the appearance, not so much of fern leaves, but of leaves that were at right angles one to the other.

In the meantime, while this is being prepared, I may show you what I have not showed you already—that we get hydrogen from water by means of this zinc foil covered with spongy copper. If I take a light we shall find that the hydrogen will burn. [A light was applied, and the hydrogen which had been collected burnt with a slight flash.]

Now I hope we shall be able to see the tin forming. It is a curious thing for you to observe that these crystals have all the same form as they had the other day. You may remember that when I showed them to you before there was no galvanic battery at all. We were only dealing with a zinc plate and a solution of tin. There was, in fact, a galvanic or voltaic cell, but it was a self-formed cell. [Upon a current being passed through the solution of tin, a rapid deposition of tin crystals from one of the poles took place.]

We will have another experiment of the same kind. We will try silver and see what crystals it gives us. Here are the two wires for the display of silver. You recollect the former appearance of silver crystals. In this case there is a growth on both poles. We have here the silver crystals forming on one side, but on the other side we have a growth of crystals too. They are differently shaped, and if you saw them properly in a microscope you would see that they were black crystals of oxide of silver.

Well, these are beautiful things to look at, and beautiful things to think about, and this strange growing—nature's first attempt at architecture, if we may call it so—reminds me very often when I look at it, of a story in a good book which I hope all of you are fond of reading, and which tells about the building of a great temple, and how all the timber and stones were prepared at a distance from that temple, and not at the place itself. We read how the cedar came from Lebanon, and other timber from elsewhere, and how the wood and stones were all got and squared according to the plan of the Great Architect; and how, when these things were all prepared at a distance, the materials were all brought together at Jerusalem by seventy-thousand strangers, who were captives, and who were made bearers of burdens. And we read that there was neither axe nor hammer, nor tool of iron heard during the progress of the building. Now this seems to me to be something like that. Here we have a beautiful building taking place before our eyes; but who are the invisible workmen, and the seventy-thousand carriers of burdens? We can see something of the plan. The design—the intention of the Great Architect in this case—is plain enough; but by what agency does he work? Clearly, in this case, we must trace the effect to a great extent by the imagination. We cannot see what it is that bears this invisible tin, and lead, and silver, or how it is carried along through this liquid. I tried a gross way of showing you this by means of balls two days ago, and we can possibly imagine how the metal may be carried all through the liquid and deposited in the right place, to build up these beautiful crystals in all their elegance.

I should like to show you some more decompositions of liquids, though I have hardly time to do so. I have here, however, a solution of sulphate of soda, and it is coloured with a little cabbage water. On passing a current through it, we see that a decomposition takes place, the sulphuric acid going to one side, and the soda to the other, and this is made evident by the change of colour.

But I want to speak of some of the great discoveries that have been made here in this house upon this matter. A good deal of the work of electro-chemistry has been done in the laboratories of this institution, and the names of Davy and Faraday are associated with it for all time. As for Davy, when first this power was made known, and when the voltaic pile was brought over to this country, he set to work, and soon began to decompose one thing after another, performing such experiments as I have been showing you—experiments with salts and experiments with metals, endeavouring to split up one thing after another, and often succeeding in doing so, and making some of the most brilliant discoveries. And Faraday afterwards followed in his steps, and showed that this decomposition was very regular—that it was connected with the chemical decomposition that

was going on in the cell—and that, in fact, as I have put in the notes of this lecture "the quantities of chemical elements separated by means of the same amount of voltaic force stand in a constant relation to one another, namely, that of the chemical equivalents." He found that there were regular numbers governing this electrolytic decomposition. For instance, if he got one part of hydrogen by decomposition, he could get with the same force 108 parts by weight of silver, or 100 parts of mercury, or 32 parts of copper. That is, the same force which would set free 100 parts of mercury would set free only 32 parts of copper. And so on with all the other elements. Of magnesium there would be only 12 parts set free. This is one of the most wonderful laws which was discovered by Faraday in this institution, and which connects together galvanism and chemistry, in the most indissoluble bonds.

Now I want to show you in the remaining five minutes some of Davy's most remarkable experiments in decomposing substances. He thought that if we could separate metals so easily from their salts, as you have seen in the case of lead, and silver, and tin, we could decompose all salts, and he asked himself whether there were not a great number of things which were considered to be elements, but which were really compounds, and he thought that he might be able to tear a metal out of them if he could get a sufficiently larger amount of force. So he took all the force he could obtain from all the batteries he could get together, and worked away at the different substances that he supposed might be compounds. Among them were potash and soda. Nobody had decomposed these alkaline earths before, and nobody knew that they were like the ordinary oxides, such as oxide of zinc, oxide of iron (iron rust), or oxide of copper; but he thought that they might be such oxides, and that if he was to try them he could succeed in getting a metal out of them. I repeated some of his experiments at this table in preparing this lecture, but though they succeeded the results were not visible at a distance. I will show them to any of you afterwards, if you wish to see them. By passing the current from the battery wires through damp potash, he was able to get out of it a metal which is called potassium—the metal which I have here. It is a very soft metal, which looks something like lead, but it is much softer than lead, so that I can squeeze it between my fingers like putty. It is also a very light metal, and will float on water, and it does something else than float when it is thrown upon water. It takes fire, as you see, and burns with a rose-coloured flame. Davy produced another metal—sodium—from soda, which is very much like potassium in its qualities. He also obtained potassium combined with mercury. He tried then the volatile alkali which we call ammonia, and he got the elements of it to combine with mercury too. I will show you this, as it can be made visible to the audience. I have a small quantity of mercury at the bottom of this vessel, and I can pass a current up through the mercury, and then through a solution of chloride of ammonium. We will look at the result after a minute or two. This discovery of potassium was, perhaps, Davy's most important discovery. He recorded the various steps in his note-book which I have here, and this of course is a very precious document. He describes the most conclusive experiment thus: "When potash was introduced into a tube having a platinum wire attached to it, and fused into the tube so as to be a conductor, *i.e.* so as to contain just water enough, though solid—and inverted over mercury—when the platinum was made negative, no gas was formed, and the mercury became oxydated, and a small quantity of the alkaligen was produced round the platinum wire, as was evident from its quick inflammation by the action of water. When the mercury was made the negative, gas was developed in great quantities from the positive wire, and none from the negative mercury; and this gas proved to be pure oxygen." Davy makes in his note book a drawing of the arrangement of the apparatus, and then he writes at the end of the account "Capital experiment, proving the decomposition of potash." A capital experiment it was!

Now you see how largely this mercury has increased in volume. It has swollen up through its combining with some of the elements of the chloride of ammonium. It is not only growing, but I can turn it out into some other vessel, and show you what sort of stuff we have got. You see it is not mercury such as it was before. It is a buttery material, which I can handle much more easily than I could handle mercury. If I had taken potash instead of ammonia salt, I might have made a combination of mercury and potassium. You see I am employing the old alchemical term in saying "mercury," instead of "quicksilver." Here I have mercury and sodium combined together, and we will pour upon it some of this chloride of ammonium, and see whether we do not get this curious compound by another kind of action. [A voluminous soft "buttery" amalgam was the result of the mixture.]

ON THE CONSTRUCTION AND MAINTENANCE OF LIGHTNING CONDUCTORS.

By R. FRANCISQUE MICHEL.

(Concluded from p. 46.)

Earth contact (*prise de terre*), properly so called, is the perfect and intimate contact that should exist between the end of the conductor and the ground or common reservoir. An early method of making earth contact consisted in multiplying the iron bars attached to the end of the conductor, and plunging them for some diameters into well-water. Theoretically, if the joints are well made, and the parts (kept clear) are immersed deep into the well, this arrangement is sufficient; but, if long neglected, this part of the system should be re-made. Besides, and I insist upon this point, one must never be contented with mere water contact; a soil well diluted in all seasons is far preferable.

To attain this end, it suffices if, as M. Viollet-le-Duc has done with his mansion at Pierrefonds, we penetrate into the moist ground to a certain depth one or several metallic branching stems connected with the conductor. On this principle a strong grating furnished with points has been constructed to be sunk into the bottom of wells. M. Callaud, of Nantes, in a recent pamphlet, describes an arrangement which he uses, in which the conductor is terminated by a kind of galvanised iron

grapnel placed in a sort of wicker basket, filled with fragments of coarsely pounded coke. In principle this idea is good. With the desire, however, to increase the surface in contact with the humid earth as much as possible, I propose to employ the galvanised grating or harrow first mentioned, and of which Fig. 7 is a sketch. My plan

Fig. 7.

is to place it between two layers of horn embers (*charbon de cornue*), which are denser than water; a first layer being placed at the bottom of the well, and the harrow forcibly sunk into it. The jointing of the conductor with this harrow should be made with all possible care, and embedded in a little heap of melted zinc.

When a sheet of water is at hand, the lightning conductor thus arranged will be in the best possible condition; but when far away from wells, ponds, or streams of water, one is limited to the moistest part of the neighbouring ground, and there to bring the conductor, and give it at that place the greatest possible development by means of suitably arranged ramifications, terminating at the feet of trees. In default of being able to do better, this "earth" may be considered as sufficient. In a town, making of "earth" for the lightning-conductors of public monuments will not present any difficulty. Main water-pipes and gas-pipes offer large metallic surfaces. It is therefore simply needed to fix the conductor to one or the other, or better still, to the whole pipe system, in order to establish good communication with the common reservoir. In some cases sewers may be utilised.

For a certain number of years, galvanised iron wire cables have been used for conductors instead of iron bars. Considering their flexibility, their erection is more easy, especially for clock towers and buildings, whose exterior access is difficult, or where architectural details are very numerous and varied; very considerable unsoldered lengths may also be obtained. Considering their pliancy, all dilatation will be resolved into curvatures of small radii, without decreasing the hold of the hooks; lastly they are galvanised, a quality not found in the iron bars of a certain length. These are real advantages. Nevertheless the following precautions must be taken:—It is necessary that the cable be under the same conditions as a bar of iron, that is to say that over its whole length the electricity divides itself between all the wires of which it is composed. Now, the wires are not united rigorously enough for their lateral contact to be sufficient. Consequently, at the contact of the stem with the conductor, the latter should be let into and soldered into a special piece of iron, and pinned and fixed, as already described in Fig. 3. On making a splice, care must be taken to cover it with solder. If one of the wires composing the cable breaks, it should, after being replaced in position, be soldered at the point of fracture. Lastly, the juncture of the cable with the harrow should be similar to its juncture with the stem, and afterwards surrounded with melted zinc.

M. Callaud, in his pamphlet, explains a method of tying to the stem which I absolutely reject. It is to worm the base of the stem, to surround it with a loop made from the cable, and to fasten this loop by a bolt. M. Callaud's cable is of copper; the contact of copper with iron will occasion a rapid oxidation of the latter metal; it will be in vain to tighten the bolt, for this joint will present a resistance more and more considerable. As a general rule the pieces composing lightning conductors should not be simply placed in juxtaposition or bolted together; all the joints should be covered with a layer of solder at least one millimetre thick.

Manifold are the questions whether, when there is a real advantage in using a metallic cable instead of iron bars, the cable should be of iron or red copper. By virtue of the differences of conductivity, a conductor of galvanised iron, 2 c.m. diameter, may be replaced by one of red copper wires half the diameter. But then the cost will be much more; besides copper, much less resisting than iron, in a mechanical point of view, undergoes with rapidity under the influence of electric currents and atmospheric variations, both a kind of disaggregation and temper, rendering it fragile and brittle—*i.e.*, in a very short time its primitive solidity is much altered. Lastly, it will always be inconvenient to employ for lightning conductors two metals (copper and iron) in close contact, since upon the latter metal oxidation will be produced. When a difficulty is met in using iron bars, I think it will be preferable to make a cable of iron galvanised wire; and in every case a diameter of 20 m.m. will be sufficient.

I will now examine two opinions broached by M. Perrot. (1.) Should the number of points at the summit of every lightning conductor stem be multiplied? (2.) Ought the large metallic masses included in the construction of a building to be united to the conductor?

(1.) Experience teaches that, on the approach of an electrified cloud, the more points there are the greater (within a certain limit) will be the neutralising effect. When a stem, according to old usage, has but one point, it acts only in one direction. But if there is a large number of stems branching in all directions, the preventive effect

Fig. 8.

will be considerably increased. This arrangement may be easily carried out by having the ordinary

conical-trunk copper arrow on the top of the stem melted down and fashioned so that, at about half its height, it will present a tolerably distinct circular swelling. Into this swelling let arrows be fixed, inclined at each side of the horizontal plane to an angle of 45°, as in fig. 8.

By using six arrows or points for each inclination, there will be twelve alternately in each direction. Radiating in all directions they will hasten the neutralisation of the electrified cloud; and, in the event of a discharge, the discharge, by dividing amongst them, will prevent their fusion.

(2.) M. Perrot considering it necessary to isolate, with great care, lightning conductors from metallic masses which form part of the building, recommends the use of a glass insulating ring. Now the elementary laws of physics prove clearly that, when a lightning conductor is in action, we may freely approach it and even touch it, since all the electric fluid runs through it alone. There can, therefore, be no inconvenience if we bind the conductor to these metallic masses: there is found, on the contrary, a great advantage therefrom; for these masses being in connection with the earth themselves, give a certain amount of preventive effects; besides, if we assume as an extreme case that they are struck, being in communication with the earth, the building will be saved.

From M. Melsen's experiments, it appears that Ohm's laws* are equally true when electricity of a high potential is concerned. He considers therefrom a great advantage is obtained in multiplying the number of conductors, at the same time to give to each a smaller section, until only a simple wire of stout diameter may be used. He likewise recommends as much as possible that the points should be multiplied around the building, so as to make it a veritable aigrette. That gentleman also enunciates the following rule:—

All metallic pieces of tolerable size should be put in communication with the lightning conductors, so as to form closed metallic circuits, that is to say by two points, or at least to two conductors.

By metals he means those which are not in communication with the common reservoir, as, for example, when they are found near the ground. For want of the ability to carry out this rule, the junction of the metallic masses should be effected as near as possible to the soil.

HOLTZMAN'S SYSTEM OF UNDERGROUND TELEGRAPH LINES.

By J. F. NIERMEYER,
Sub-Director at the Central Telegraph Station at Amsterdam, Holland.

The want of underground telegraph lines has been felt since telegraphing commenced. Every telegraph book and periodical contains lamentations about inconveniences attending the overhead system, and the high cost of continual repairs and maintenance. A thoroughly good and cheap underground system will accordingly replace advantageously the defective overhead system.

Mr. A. Holtzman, at Amsterdam, Holland, has done a great deal in this way.

Finding almost all the qualities of gutta-percha in a bituminous compound named *brai liquide*, not to be confounded with other bituminous compounds, he has spent a great deal of money in making experiments with it on a large scale, first to replace the gutta-percha by his compound, and afterwards to use it as a protection for a very small and consequently cheap size of gutta-percha wires.

The method of constructing lines in the open air by bending copper or iron wires in cast-iron gutters, and filling them up afterwards with melted compound, proved itself too much dependent on weather and temperature.

The experiments of fabricating telegraph cables with the compound succeeded perfectly well, but the expedition of the cables being too difficult, that mode of exploitation was abandoned, and the studies were continued in another direction.

A good underground line should be almost everlasting, and therefore care had to be taken to have the outer protector made of a strong, tough, durable material. The interior protector must be invariable, elastic, insulating, air- and water-proof, not subject to chemical influences, and not acting chemically on the insulating material with which the conducting wires are covered. The gutta-percha coverings must be of a size sufficient for a good insulation among the conducting wires, and by those coverings a sufficient distance to prevent galvanic induction should be maintained among the wires. If necessary, a single or double tape could make the distance longer. For outward protector were chosen gutters of strong, thoroughly creosoted firwood, it being proved by the experience of half a century that wood is the most strong and invariable of all substances.

The compound should increase the insulation of the conducting wires, protect them against desiccation by surrounding them everywhere, and never, under any circumstances, must it be given to hardening and consequently breaking or splitting. The *brai liquide* possesses all those qualities, as has been attested by many experiments. It melts at a temperature of 70° to 80° Celsius, and remains plastic even at 15° under zero.

Very interesting experiments have been made by chemical men to examine if ever the compound can in any way injure the gutta-percha by influencing chemically on it. It is found that by coal-tar distillation the nuisible substances are extracted first, and if perchance there should be left a little of them, they will be so much mixed up with and dispersed in the compound as not being able to give any nuisance.

For having a fair trial, 60,000 metres of gutta percha wires No. 7, making a line of twelve wires at 5000 metres length have been put, without being taped, in gutters filled with melted compound. Finished in August, 1873, this line still shows a perfect insulation, while the compound and the gutta-percha are both in a very good state. A second experiment has been taken with several gutta-percha wires laid in a solution of 50 per cent *brai liquide*, and 50 per cent oil of creosote. After having remained two years in this compound, the gutta-percha is entirely unchanged.

If, nevertheless, there could remain any doubt on this subject, very reliable and easy means are left to protect the wires against all possible corruption by tar oils. I will gladly give information to anybody who wishes to know those means.

* The laws of the distribution of electric currents in conductors, and the laws of derived currents.

The materials being known, a short description will do for knowing all about constructing the lines.

After having dug a ditch of about 30 English inches deep, the gutters are placed as much as possible horizontally on the bottom of it and steadied; when necessary, at intervals, by a piece of wood. The joints are made by bringing the ends of the gutters towards each other in a block of creosoted wood carved out for that purpose, and by strongly nailing them on the said connecting block. Afterwards the gutters are filled with liquid, Holtzman's compound, melted in iron tubs.

The compound being cooled down to 30° or 40° Celsius, the wires or cables (covered or not with the anti-oil substance) are put in the compound and covered with it. The compound then is still sufficiently liquid without being able to injure the gutta-percha. The best and easiest way of knowing the temperature of the compound is putting the hand in it.

Care must be taken to have the gutters filled at once before laying the wires in them. The wires then are put in and surrounded on all sides with the compound. This done, the coverings are strongly nailed on the gutters, the ditch is re-filled, and the work is finished.

As the invariably tough and plastic compound gets a strong hold of the strong and indestructible gutters, injuries to such a line cannot possibly occur. Against sinking away and breaking in a swampy soil, precautions must be taken; besides these cases, only a volcanic eruption can injure it.

The line of 60,000 metres near Amsterdam is put in a very bad swampy soil; nevertheless splits do not occur.

No. 5 of the *Journal Telegraphique* of Berne, dated 25th March, 1870, contains a description of experiments taken in Cologne, with underground cables. Speaking of the bitume which had been covering the cables about fourteen years, it was mentioned as being stone hard (*dur comme la pierre*). I believe this is just what should be avoided for telegraphic purposes. If the said cables were buried very deep, they may perhaps not have been shaken by riding above them, but the bitume growing so very hard. I think it very much subject to breaking or splitting, which will be always a very dangerous evil. As aforesaid, the Holtzman's compound can not grow hard nor split, because it is shut up in the gutters, and this is doubtless a very valuable quality of the system.

A second advantage is the opportunity of increasing the number of conducting wires at little more cost. The price of the Holtzman lines is much lower, as that of the cable system. With a line of fourteen wires it differs more than half of the price; when increasing this number, the difference becomes too great for comparison. Every one can calculate the amount of what an underground line costs. The prices of creosoted wood and gutta-percha wires are known everywhere; the compound costs fifty shillings a 1000 kilos. A cubic metre of compound weighs 1240 kilos.

Other costs as for digging a ditch and re-filling it, putting the gutters, melting the compound, filling the gutters, laying the wires in them, and putting the coverings, can be also easily calculated. Twelve labourers can construct daily about 200 metres of line. One of them must be perfectly acquainted with making gutta-percha joints, and, of course, all must be constantly and scrupulously controlled.

Having thought it my duty to make universally known a method of constructing telegraph lines, which I am convinced is not only cheap but also reliable, and wishing to promote the introduction of it everywhere, I will gladly and without any cost inform anybody who wishes to know more about it.

THE TALE OF A RAT.

It having become necessary on a recent occasion, in one of our large provincial towns, to withdraw a cable of gutta-percha wires from some iron pipes, in a busy thoroughfare, the inspector in charge commenced operations shortly before midnight, to avoid the crowding which otherwise generally attends such feats in the daytime. The flush boxes being opened the men commenced hauling, the wires travelling with remarkable ease, till suddenly the workmen were interrupted by a shout from the inspector. They had forgotten to attach the iron wire to the other extremity of the cable, which is indispensable to the pulling in of a new or the return of the old cable when necessary. However, it was no use crying over spilt milk; the cable could not be thrust back, so the work was concluded, the boxes closed, and our friend retired to a restless couch with the conviction that he had done a stupid thing. After sundry turnings and twistings a "happy thought" struck him, and, his mind at rest, he fell into deep repose.

The following day at the same hour, having invoked the aid of a rat catcher, and, armed with a large rat, a ferret, and a ball of string wound on a Morse paper drum, he returned to the scene of his former exploit. The boxes were opened, and the rat having previously had one end of the string firmly attached to his body, was put into the pipe. Charmed with unexpected liberty, monsieur scampered away at a racing pace, dragging the twine with him until he reached the centre of the length of pipe, when he stopped to investigate matters. The ferret was then put in, but the sight was enough. Off went the rat again until he sprang clean out of the next box. One length was thus safe, and the same operation was commenced with the other; but the rat objecting to be made a cat's paw of, stopped short a few yards in the pipe, and boldly awaited the approach of the ferret. A terrific combat then commenced, cries and shrieks reaching the ears of the alarmed spectators outside, who dreaded, not only an utter failure of the second operation, but a stoppage of the pipes by one or more dead bodies. After sundry violent jerks had been given to the string however, the combatants, alarmed at such unexpected interruptions, separated; the ferret returned to his master, and our friend the rat, making for the other extremity of the pipes, carried the string right through, and so relieved the inspector from his anxiety.

The traffic receipts of the Great Northern Telegraph Company for the month of February were, this year, 256,146 francs; last year, 293,206 francs. Total traffic receipts 1st January to the 28th February, this year, 522,167 francs; last year, 617,672 francs.

Notes.

Leeds is setting a capital example in establishing an Exhibition of Scientific Apparatus, illustrating—and necessary for studying or teaching—the various branches of Natural Science. The object is essentially educational. It is hoped that our instrument-makers—especially those of magnetic and electric apparatus—will forward the scheme by making large exhibitions. No charge is made for space, and amateurs are specially provided for.

An ingenious engineer of Glasgow, Mr. Alley, has applied the expansion of thermometer due to heat to complete a circuit, and to indicate—by ringing a bell and moving an indicator—the heating of the bearings of machinery.

In *All the Year Round* for February there is an excellent description of Silvertown, and its various manufactures and operations.

The India-Rubber, &c., Company have issued their Report, and it proves a contrast to the reports of the other construction companies; for though they have netted a good profit, they are unable—owing to their misfortunes in the West Indies—to declare a dividend. The Company are adopting the novel practice of making and laying a sound cable, and developing a business before selling it to the public. They did so in the case of the Spanish Direct Cable, and are just sending out an expedition to Chili and Peru for this same purpose. The public are more likely to be better served by this practice than by subscribing to a new Telegraph Company whose cables are neither made nor laid, and whose returns are neither known nor developed.

The Central American Telegraph Company announce that they have received information to the effect that the line from Para to Cayenne and Demerara, as also the lines from Trinidad to St. Croix and Porto Rico, have been successfully completed, thus giving direct telegraphic communication between Brazil, the West Indies, and North America. These lines will, in accordance with agreements, become the property of the West India and Panama Company.

The traffic receipts of the Western and Brazilian Telegraph Company, Limited, for the four weeks ending the 26th of February, were £8842.

The number of messages passing over the Cuba Submarine Telegraph Company's line during the month of February was 2079, estimated to produce £2200, as against 683 messages—producing £478—in the corresponding month last year.

The Eastern Telegraph Company's traffic receipts for the month of February, 1875, amounted to £32,765, against £31,084 in the corresponding period of 1874.

The Eastern Extension (Australasia and China) Telegraph Company, Limited, notify that their traffic receipts for the month of February, 1875, were £16,415, against £17,706 for the corresponding period of 1874.

The fourth International Telegraph Congress will meet on the 1st of June, at St. Petersburg, in conformity with the decision arrived at, at the Roman Congress. The Russian Government some time since forwarded invitations to the twenty-four States which have adhered to the Convention, and to twenty Submarine Telegraph Companies. With the exception of the United States, all have accepted. The British Post Office will be represented by Mr. H. Fischer. Brazil, the Argentine Republic, and Japan, are the new States which will be represented at the Congress, which is expected to last forty days. The private companies have only a consulting voice, the official representatives of States alone having the right to vote.

Mr. Charles Burton, Director-General of Telegraphs for the Argentine Republic, and Honorary Secretary of the Society of Telegraph Engineers, has just left England on his return to Buenos Ayres. Since his sojourn here he has been making himself familiar with our system, and on his return will probably be able to introduce some improvements into the Argentine working. He contemplates introducing the duplex system of working.

An exceedingly ingenious and pretty application of Electricity has been received from Paris. It is an electric "tinder-box," or lamp-lighter. It is the invention of MM. Voisin and Dronier, and its principle is described in vol. ii., p. 225. A little spirit-lamp, charged with benzole, is placed beneath a fine "spongy" platinum wire. A knob or plunger is depressed, which dips a zinc plate into a solution of bichromate of potash in which two carbon plates are fixed. This completes a circuit of which the platinum wire forms part, and which consequently becomes *red* hot by the current, *white* hot by the hydrocarbon fumes, and thereby hot enough to inflame the benzole. One of these instruments is said to be able to furnish 15,000 lights before the zinc requires renewal. It is a novel application of Electricity to domestic purposes, and a useful adjunct to a house. It is about the size of a small money-box or tobacco-jar, and stands well and ornamentally on the chimney-piece. Its price is 15s., and it is sold by Alabaster and Co., 57, Ludgate Hill, London.

The *Ambassador*, with the cable for the River Plate, left on Saturday, the 27th inst.

ELECTRIC EARTH BATTERIES.

In the year 1838, Steinheil made, on the railroad from Nürnberg to Fürther, an experiment in using the rails as conductors for telegraph despatches; but he found that the current passed through the earth from one rail to the other, and then he conceived the idea of using the earth for the return current, thus saving half the wire. He found that it not only worked perfectly, but better than a wire for the return current, as the earth and one wire gave only half the resistance given by two wires, which were used before this great discovery, which was of the utmost practical importance to the progress of the telegraphic art. The manner in which this method of using the earth for the return current is applied is to bury, at each of the two terminal stations of the line, a copper plate in the moist earth, and connect it by means of a wire to the telegraph apparatus or battery. Gauss, in repeating this experiment, conceived the idea of leaving the battery out altogether, and burying at one station a large copper plate, and at the other a large zinc plate; and he found that a powerful electric current then passed through the wire. This arrangement is evidently nothing but a single voltaic pair, constructed on a large scale, as the layer of moist earth of a few miles in thickness between the metallic plates replaced the layer of acidulated cloth, paper, or liquid in the cell.

Bain applied this arrangement to his telegraph, so as to obtain a current of long duration and constant quality. He buried a series of zinc and copper plates, opposite to one another in the moist earth, and connected them by insulated wire; and so obtained a current of sufficient strength to work his telegraph. According to the same principle, a variety of voltaic batteries or generators of electricity have been constructed, by means of which Bain, as well as Robert Weare, kept his electric clocks in constant and very regular motion. Such an earth battery remains in similar activity until, in the course of time, one of the metals has become entirely oxidised, which oxidation, according to experience, takes place only very slowly when large plates are buried deep in the moist ground.

The most extensive application of such batteries was made by Steinheil on the railroad from Munich to Nanhofen; the line was 22 miles long, and the earth battery was completely successful in performing not only the service required on the road itself, but also in serving for the sending of despatches for the public. The metal plate in Munich was of copper, of 120 square feet, while in Nanhofen a zinc plate of the same size was buried; both plates were sunk so deep as to reach the level of the subterranean well water of the locality, and connected with isolated wires to the air line. The current thus established was used to effect the deviation of a magnetised needle in a galvanometer, which Steinheil used as the basis of his system of signals, a system requiring only a very feeble electromotive force, a force entirely insufficient to move the electromagnets of the Morse system, or the hand of a dial telegraph.

The construction of such earth batteries, easy and simple as it appears to be, has never become a settled practice, for reason of the laborious digging required, it being much easier to plunge plates in cups and renew them after a while, than to dig up the oxidised zinc plates in order to replace them by new ones. However, when a river or brook is at hand, the practice can be recommended; as in that case a zinc plate has only to be sunk at a convenient and safe spot. Then at any time, if the current becomes weak, the plate may be easily replaced by a fresh one; while in place of the copper, a quantity of coke may be buried in the moist earth. The great objection to this form of battery is, however, the unavoidable total lack of intensity: as the latter quality depends on the number of cups, and the earth or water acts as but one single cup, and thus the burial of several plates is equivalent only to the immersion of them in a single cup. If the plates are connected for quantity, that is, all the zincs together and all the coppers or cokes together, the series will act like a single pair of which the surface is equal to the sum of the individual plates, and thus as one pair of large surface; if, however, the plates are connected for intensity, that is, every alternate zinc to the next copper, only the two plates at the extremes of the series will be of use, because the several intermediate pairs discharge mutually all the electricity generated into the moist earth, through their metallic connections, which shows the fallacy of the advantage claimed for some earth batteries lately constructed and even patented.

Of all the batteries thus far constructed, the most constant appears to be that of Leclanché; it is to a certain extent an imitation of an earth battery. It consists of a large piece of coke surrounded by coarsely pulverised manganese and coke, all contained in a porous cell and surrounded by amalgamated zinc plunged in a solution of sal-ammoniac. This battery has, during the last ten years, been more and more used in France; and according to the testimonies of the telegraph operators there, it far surpasses all others, for reliability and constancy.—*Scientific American.*

Proceedings of Societies.

SOCIETY OF TELEGRAPH ENGINEERS.

Wednesday Evening, February 24, 1875.

Mr. Latimer Clark, President, in the Chair.

After the usual business had been transacted, the President announced the completion of the formalities respecting the gift of the Ronalds Library, and that in the course of a few days the books would be transferred to the Society's rooms. The Catalogue in Sir Francis Ronalds's handwriting was in the possession of the Society, and a portion of it was exhibited to the meeting.

The paper read was "*On Induction between Suspended Wires as affecting Automatic Transmission*," by R. S. Culley, Vice-President. It had been noticed in the automatic working of the London and Dublin circuits over the new Holyhead line that certain interferences took place, apparently of a character similar to contact between the wires. During the interruption—in August, 1874—at the Holyhead-Howth cable, experiments were conducted by Mr. A. Marson, of Mr. Culley's Staff, to investigate the causes of these interferences. A careful series of experiments proved that the causes were entirely due to induction. The wires in question—four in number—proceed under-ground from the Central Station to Paddington; thence along the Great Western Railway to Chester, *via* Oxford, Birmingham, and Shrewsbury; from Chester they are carried along the main road (with the exception of a short section on the Anglesea Railway) to the cable hut. The total lengths were—Under-ground, 10 miles 1648 yards; road, 75 miles 833 yards; railway, 216 miles 1457 yards; giving a maximum length of 216 miles 1457 yards. These wires were of No. 4 B.W.G. as far as Chester, thence of No. 8. Two wires

were principally experimented on: the two lowest wires on the pole the farthest side of the railway; the upper being in an arm 33 inches long, the lower in one 24 inches, the distance between the arms being 12 inches. In the experiments a Bain's chemical decomposing apparatus was used, fitted with two styles, the one insulated from the other; the metal band over which the chemically-prepared paper passed was also insulated. The one style was connected with one of the wires, the other direct to earth. The paper was prepared with potassium iodide. To the second wire under experiment was attached a key with a battery of 100 cells. It was found that as this wire was disconnected at Holyhead, Chester, Birmingham, &c., and signals sent, marks became visible on the chemically-prepared paper: these marks—varying in intensity and length on the length of line disconnected—decreased, until they ceased altogether, when only the Paddington under-ground was alone in circuit. The mark made on the paper was of a "comet" or "tadpole" form, and lasted but a short time, no mark being visible whilst the key remained depressed, but immediately the key was released a more elongated dash appeared at the style connected with the earth. When the wires were disconnected and put to earth—at Holyhead, Chester, Birmingham, Oxford, Reading, and Paddington successively—it was found that the marks were always tapering and gradually reduced in magnitude when the line was disconnected, but when it was put to earth the marks became square-ended dashes. A double-current key, sending reversals, was found to give increased effects; and the various phenomena observed agreed perfectly with the well-known laws of Induction. Numerous wires were experimented upon, and the results came out in accord with those laws. The induction was greatest with two wires suspended only about 12 inches apart; it was much less between the two wires on the same arm, 24 inches long; and very much less between two wires in an arm 33 inches long. It would appear that it will in future be necessary to allow greater space between suspended wires when pursuing the same route for many miles, as in high speed automatic transmission interference—whether by induction or contact—would be undesirable. It was remarkable that in the long under-ground lines formerly in work between London, Manchester, and Liverpool, no induction had ever been noticed between wire and wire, whilst between wire and earth the induction was so great as to materially interfere with working. Similarly, in some carefully-conducted experiments extending over some hours, on two of the wires in the North Sea cables, no interference was observable to be due to the ordinary working of the other lines.

Mr. Preece then explained the phenomena and action of induction, &c.

A ballot took place, when the following candidates were elected:—

Foreign Members.—Lieut. Frederick Dreyer, Royal Danish Navy, Great Northern Telegraph Company, Shanghai; Lieut. Edouard Luenson, Royal Danish Navy, Great Northern Telegraph Company, Copenhagen; Don Rafael Gimenez, Santiago; Don Luis Zignago, Federacion, Argentine Republic; Don Manuel Ramira, Antonio Tomas, Argentine Republic.

Members.—John Fuller, Stratford; Bennett Pell, Eastern Extension Telegraph Company, Singapore.

Associates.—Shotto McK. Douglas, Eastern Extension Telegraph Company, Singapore; George Fuller, Stratford; Conrad W. Cooke, Marlee Terrace, Clapham; R. Price Williams, Great George Street; George E. Dering, Lockleys, Welwyn; Henry Starke, Government Telegraph Department, Brisbane, Queensland; Jacques Ducloy, Submarine Telegraph Company; Major Granville Puget, 34th Regiment, Carlisle.

Inaugural Address, by Mr. Latimer Clark, President. January 13, 1875.

(Concluded from page 58.)

I must now take leave of the Electric Telegraph Company, with which I was so long and pleasantly associated, merely recording that its successive Engineers were Mr. W. H. Hatcher, Mr. Edwin Clark, Mr. Latimer Clark, Mr. Cromwell F. Varley, and Mr. Richard S. Culley. The Company has now become merged in the Tleegraphic Department of Her Majesty's Post-office, and under the able administration of that department its growth and progress have outstripped the most sanguine calculations.

On the 30th of last June, the Post-office system comprehended 106,730 miles of wire, and 1451 miles of submarine wire, exclusive of Railway Companies' wires, and of the Continental and other cables of the various Telegraph Companies. The number of telegraph offices open to the public on the 31st of December was 5572, and the number of telegraphic instruments in commercial use was 9220. The growth of the traffic may be seen from the number of messages, which was as follows:—

December,	1871	11,760,518
,,	1872	14,858,020
,,	1873	17,294,334
,,	1874	19,116,634

It is gratifying to observe that the consolidation of the telegraphs into a Government system has in no way tended to retard the progress of telegraphy, or to discourage invention. Although the able officers of the Government must have been at times hardly taxed to meet the growing requirements of the service and the difficulties incident to the transfer of a vast network of rival telegraphs and their consolidation in one centralised system, they have been throughout among the foremost to seize upon every scientific invention or idea, and to test its practical adaptability to the wants of their system.

I could have wished to have touched further upon the history of the other Telegraph Companies, to have spoken of the introduction of the Pneumatic system, of the various automatic and type-printing telegraphs, of the duplex system, and of the exquisitely scientific instruments of our retiring President Sir William Thomson; also of the history and development of submarine telegraphs, of underground wires, and of the progress of telegraphy in other countries; but time forbids, and I must reserve space for a few words about ourselves.

I believe the present Society owes its existence chiefly to the wisdom and energy of Major Frank Bolton and Major Webber, R.E., who foresaw the probable success of the institution, and the benefits which it would confer on all engaged in telegraphic practice or electrical research. As we are all aware, it has been warmly supported by the profession both at home and in foreign countries, and, what is still more gratifying, our list of members comprises the names of some of the most eminent scientific men of the age, and of many who are entirely unconnected with telegraphy. I should like to see this division of our forces greatly extended.

I remark with pleasure that several of our great Submarine Telegraph Companies have given us cordial support, and their officers, who are so exceptionally well circumstanced for making observations of the highest value, have contributed admirable papers to our *Transactions*. We have also been fortunate in receiving the valuable co-operation of the department of Royal Engineers, and many of our best papers have emanated from that highly scientific body.

Our *Journal* continues to maintain its character It has now reached its seventh number, and is becoming a work of considerable historic and scientific value.

Our example is beginning to be followed in other countries, and already an American Electrical Society has been constituted in Chicago.

The present number of our Members is 650.

I will not occupy your time by giving a list of the telegraphic works which have been executed during the past year, since they are well known to most of us, and are abundantly recorded elsewhere. But I will refer to a few of the more interesting novelties which have recently occupied our attention. Among these, I give the first place to the reintroduction of the Bain system of telegraphing by punched paper and chemical decomposition, to which I have alluded in the earlier part of my discourse—if the promises which this system appears to hold out are realised, it will have a powerful influence on telegraphy.

The next discovery I would notice is that of Mr. Edison, of Newark, U.S., who has made the interesting observation that when an electric current traverses a strip of paper moistened with certain solutions it acquires an extremely slippery surface, and taking advantage of this, he has constructed an instrument which may hereafter prove of much value in telegraphy.

Mr. Elisha Gray, of Chicago, has turned his attention to the transmission of signals by sound—he has exhibited instruments by which musical sounds and even chords are perfectly transmitted over telegraphic wires, and by his latest researches he finds that seven or eight or more different sounds can be all transmitted simultaneously over one wire, and, by springs vibrating in unison with the several notes, can be separated at the end. He is now engaged in applying this principle to telegraphy with prospects of success.

M. Clamond of Paris has so improved the well-known thermo-electric pile as to render it probable that it may to a great extent supersede the use of the ordinary voltaic battery.

The Duplex system, now so well known, has been also re-introduced from America, and I allude to it here, not only to point out the activity of thought and invention that is now going on in America and on the Continent, but to show how much remains to be done by original research and experiment, and how desirable it is that we should re-investigate, with the aid of the improved knowledge and appliances we now possess, the inventions and ideas of our predecessors. A boundless field now lies open to research, and I trust before long this Society may be in a position to offer the advantages of a laboratory, of electrical instruments, and of artificial lines and cables, to any of its members who may desire to prosecute fresh researches.

I have no doubt the most interesting and gratifying part of my address will be the announcement I am able to make to you this evening, that the acquisition by this Society of the valuable library of our late lamented member Sir Francis Ronalds is now complete. Our sorrow for his loss is tempered by the remembrance that he lived to witness, to an extent perhaps never before vouchsafed to man, the wondrous success and development of that telegraphic system which he had done so much to perfect and to advance in his early life, and by the gratification which we know it afforded him to receive at the hands of his Sovereign a well deserved recognition of his services to his country.

By his will he bequeathed his library, which it had been the amusement of his life to perfect, to his brother-in-law, Mr. Samuel Carter, of Battle, and this gentleman, in fulfilment of Sir Francis Ronalds's desire, that the library should be made available to all students of electricity, has transferred the whole in trust to this Society, with a reversion to the Royal Society, of which he was so distinguished a fellow, in the event of this Society becoming extinct. The deeds are now before me approved and only requiring execution. Among other provisions it is stipulated that the collection shall be termed the "Ronalds' Library," and that we shall at once publish the complete catalogue, which it has been the labour of his life to perfect; also that under due restrictions the library shall, as far as possible, be open to all who desire to consult it, and that we should apply for a charter of incorporation.

I do not yet know the precise extent of the library, but I observe that in a letter of the 29th March, 1870, to the Right Hon, W. E. Gladstone, acknowledging his intimation that Her Majesty had expressed her intention of conferring the honour of knighthood on him, he says "this procedure may tend, in some small measure, to promote my endeavour to complete a much required Electrical Library, of which about 10,000 books and other writings are collected, the fruit of many years' search, and which I intend to bequeath or give to public use."*

This valuable collection of works will shortly be transferred to our rooms at Broad Sanctuary, and supplemented by the complete copy of the *Transactions of the Royal Society*, recently presented to us by Mr. Louis Crossley, of Halifax, and, by the gifts of others already promised or presented to us, and by our own purchases, it will form one of the most complete special libraries in the world.

I can assure our Members they will find the older writers, as well as the more modern ones, well worth their attentive perusal, and full of suggestive thought and experiment. Occasionally they will meet with surprises as regards priority of discovery. Even in my own cursory reading I have been interested to observe that Galvani was not the first to discover the galvanic convulsions of the frog. That that elegant instrument the Peltier electrometer was an English invention of the last century. That Oersted was not the first to observe the influence of the galvanic current on the magnetised needle. That Wheatstone was not the earliest originator of the electric balance, and that Thomson was not the first to use the instrument we familiarly know as the "Mouse Mill," or to perform the beautiful experiment of dropping zinc filings through a copper funnel in order to discover the difference of potential induced by the two metals.

There is only one other subject on which I will detain you this evening, and that subject is no other than the constitution of the Society itself.

This Society, as you are well aware, has been modelled on the lines of the parent Society—the Institution of Civil Engineers; our rules, our constitution, and our proceedings, have all been closely copied from theirs. Our object is the general advancement of electrical and telegraphic science, and most fully have the hopes and intentions of the founders of the Society been thus far realised.

As a natural result of our close imitation of the illustrious body in whose rooms we are now assembled, our proceedings and constitution have assumed, in a marked degree, a technical character, and there are those among us, and I confess I am one among the number, who consider that, while giving the highest consideration to practical telegraphy and applied electricity, we shall fail in covering all the ground which rightfully belongs to us, if we do not equally cultivate both of the objects of the Society, and endeavour to attract the lovers of pure science, and to make ourselves as much an Electrical Society as a Society of Telegraph Engineers. Any one who will revert to the inaugural address of our distinguished first President, and to the observations of those who spoke on that occasion, will perceive that that feeling is a very prevalent one, and one worthy of our attention. It is true that our technical character is, in one sense, a

* It is believed that the Catalogue contains a list of about 10,000 works and pamphlets, and that the library consists of about 5000.

great source of strength, and it has, doubtless, been the means of attracting many Members who join our ranks, partly on account of the professional value and interest of our papers, and partly from a feeling of professional *esprit de corps*. It would be most unwise to take any steps which could by possibility weaken this feeling, but at the same time it behoves us to observe that we have not yet enrolled in our ranks, to any great extent, that large body of private scientific workers who love and pursue the science of Electricity without any thought of regarding it as a profession. The earliest society of this character—"the London Electrical Society," which was established in 1841 under the able presidency of our distinguished Member Mr. C. V. Walker, F.R.S., and whose proceedings form a valuable contribution to the history of Electricity, relied entirely on the support of this class of members: and the rapidly increasing appreciation and love of physical science, has caused, and will cause, their numbers to increase immensely; and it is among such as these that we may confidently look for the brightest discoveries of electric research. Now many of these will ask themselves what right have I to consider myself eligible among a Society of Telegraph Engineers, or what affinity have I with them?

The Royal Society will ever attract to itself the most important papers on subjects of high philosophical research, but other societies will certainly arise to fill the electric void if we leave it vacant. Already the want has been felt, and a *Physical Society* has been constituted, which is destined, doubtless, to attract many lovers of pure electrical science, who would willingly join our ranks if the character of our Society were more adapted to their requirements.

It has been suggested that some friendly alliance or amalgamation might be formed with this young but important Society, and if anything of the kind is to be attempted, or any effort is to be made to give our own Society a more purely scientific character, it is evident that it should be done soon or not at all. Possessed of these views, I have gladly welcomed a proposition that I should become a Member of the Council of the "Physical Society," and should I be elected to that office, would use my best efforts for the harmony and welfare of both Societies. It is probable that this important question will be again brought under your notice, but in the meantime I have thought it of sufficient interest to address you upon it from the chair.

I have now, Gentlemen, to thank for the patience with which you have listened to my remarks, and to ask you all to lend your earnest assistance and co-operation throughout the year in endeavouring to increase the influence and prosperity of the Society of Telegraph Engineers.

Correspondence.

CLOSED CIRCUITS.

To the Editor of the Telegraphic Journal.

Sir,—In the number of your Journal for January 15th, I find the question asked, "Why is the closed circuit system not in use in England?" The first idea that would strike one as to the disadvantage of the closed circuit system would be that the battery is continually in action when the line is not being worked, and that, consequently, a large unnecessary consumption of battery materials is occasioned. Here, however, I am met with a difficulty. On referring to Mr. Culley's Handbook, fifth edition, p. 16, I find that the osmotic action which takes place between the liquids in the Daniell's battery (such being the kind I believe, almost universally used in England) is [illegible]ated to be assisted by the current. This being the case, a further disadvantage in the use of the closed circuit system appears. But on referring to another authority, viz., "The Electric Telegraph," by Robert Sabine, p. 223, I find the following:—"Another cause of the inconstancy in the action of the Daniell's element arises from the solution of copper entering the chamber appointed for the solution of zinc. This process of destruction of the element takes place faster during the time the circuit is open than when it is closed." Still further, on referring to the number of the *Electrician* for Feb. 7th, 1862, I find the following, which refers to a visit made to the instrument room of the Electric and International Telegraph Company at Telegraph Street:—Our attention was directed to what appears to be a very efficient and economical method of working a circuit of moderate length, in which several stations are included, by means of one battery at either of the extreme stations; whereby the expense and trouble of a battery at every station is avoided." After describing at some length the arrangement of keys, &c., the writer goes on to say: "It might be supposed that the continuous action of the battery would be attended with a great expenditure of material." This, however, does not appear to be the case; the increased consumption of zinc in the production of voltaic effect being compensated in great degree by the diminution of *exosmosis* of the upper solution in the porous vessel of the battery cell, while the battery is in action—the escape of this solution and its action upon the zinc element being a source of waste, which in practice is greater than the legitimate wear and tear of the battery.

As the telegraphists of America probably incline to this latter view of the case, and those of England to the statement of Mr. Culley, the difference in the methods of working may possibly be accounted for thereby. The question then arises which takes the correct view of the case.

Inquirer.

Electrical Science in English and Foreign Journals.

Annalen der Physik und Chemie, von J. C. Poggendorff. 1875. No. 1.

The Electric Conductivity of the Chlorides of the Alkalies and Alkaline Earths, as also of Nitric Acid in Aqueous Solutions.—F. Kohlrausch and O. Grotian.

Electric Sparks.—K. Antolik.

On a Universal Meteorograph for Solitary Observatories.—E. H. v. Baumhauer.

Continuation of Researches on Steel Magnets.—A. L. Holz.

On the Measurement of Angles, by Means of the Eye-Piece Micrometer, of Astronomic Telescopes. M. Matern.

Relation of Specific Heat under Constant Pressure and Volume.—J. J. Müller.

Observations on Gaseous Spectra.—E. Goldstein.

Spectra of Gases.—W. Wüllner.

Speed of Sound in Water in Pipes (preliminary communication).—V. Dvorak.

Bulletino Telegrafico. Anno x. December, 1874.

The non-official portion of this number contains a continuation of the paper on the Telegraphic Administration in England (commenced in the October number), taken from *Fraser's Magazine*. There is also a full account of the loss of the *Plata*, and a notice of the machine for recording votes in legislative assemblies (see Tel. Journ., vol. ii., p. 72).

The traffic receipts of the Direct Spanish Telegraph Company for February were £1104, against £1654 in January. The Lizard and Santander Cable was interrupted during the whole of February.

Post-Office Telegraphs.—Statement showing the total number of messages forwarded from Postal Telegraph Stations in the United Kingdom during the week ended the 27th February, 1875, and during the corresponding week of 1874:—1875, 350,846; 1874, 329,245; increase in the week of 1875 on that of 1874, 21,601.—Week ended 6th March:—1875, 352,293; 1874, 336,979; increase in the week of 1875 on that of 1874, 15,314.

The *Journal des Debats* notices a very ingenious application of electricity applied to voting in the National Assembly. Electricity is already used in the theatre which French legislators have adopted as their debating-house. The numerous gas-jets which light up the House in winter are ignited by electric wires, which operate instantaneously, to the great delight of country visitors, who are not aware of the progress which their representatives have made in the art of saving time. French Deputies, however, should not be content with this innovation—they should adopt a system of voting somewhat less awkward and unsatisfactory than the plan now in use. The House generally "divides" several times, and, except when a show of hands, or rising and sitting suffices, servants wander about the House with huge tin boxes, into which the members drop a white or blue card, accordingly as they vote "Yes" or "No." The cards have then to be sorted and counted before the result can be proclaimed. This is a long and tedious process, and an unsatisfactory one in this sense, that a member can vote for all his absent friends, and sometimes forgets to do so, or votes for a friend against the friend's opinion. A clerk employed in the Government Telegraph Office (M. Jacquin) has conceived a system for recording votes by electricity. The *Debats* decribes it in the following terms:—"Before every Deputy two ivory buttons are placed, like the buttons of electric bells. If the Deputy wishes to vote 'Yes,' he presses the button on his right; if he wishes to vote 'No,' he presses the button on his left. The voter establishes by this means an electric communication, which is transmitted to an apparatus close to the President and his secretaries. Every time the electric current acts thus it opens the door to a ball, and the ball falls through a tube into the ballot box. The balls are made of glass or ivory, and are strictly identical in weight. The two ballot-boxes are then weighed, and the number of balls is indicated by the weight. Finally, by turning a handle all the balls which have not been used are let out, and they give the number of members who have abstained or were absent when the vote was taken. Nothing can be more simple. M. Jacquin has offered to set up his apparatus in the Versailles Assembly for the sum of 60,000 frs. Time is money." The *Debats* mentions also another plan invented by M. Martin, a well-known electrician. M. Martin's plan does away with the scales, which might not always be true. Accordingly, as the vote is black, a piece of coloured pasteboard appears instantaneously above a line bearing the name of the Deputy. Before each Deputy is a small box, supplied with two buttons. When he presses on one or the other, he discloses the piece of white or black card on the board. This system has much in common with that used in hotels to indicate the number of the room from which the electric signal has come. The sum total of the votes for either side is marked on a totalising board. The advantage of this system over that presented by M. Jacquin is, that it enables the President to see whether a Deputy has not voted because he abstained or because he was absent. A member can, by placing his hand on both buttons, vote at once "Yes" and No," and be thus numbered among the abstainers. It cannot be said, however, that any benefit is conferred on the Chamber by enabling its members to record the votes of abstainers. French Deputies are too much given to manifesting their indifference in this way, and it can hardly be of much importance to constituents to know whether their representatives did not know which way to vote, or whether they were absent.—*Times*.

Dr. Stephan, the head of the Post Office of the German Empire, has been directed to take charge provisionally of the Telegraph Department, with a view of amalgamating the two departments, as has been done in Great Britain.

The Western Union Company have fitted up in their new offices in New York 7000 cells of the Callaud or gravity battery—the average weight of each cell being about 20 lbs. They employ in their operating room 215 males and 75 females, separating the latter from the former by a partition eight feet high! There are 87 tables in this room, each constructed for four sets of apparatus, and intersected by framed clear glass partitions 12 inches high to separate the sound of the instruments from each other. There is a daily transmission of about 27,000 messages, and there are:—

Morse instruments (Sounders) ..	149
Phelps' printing instruments ..	6
Duplex	15
Quadruplex	7
Milliken's automatic repeaters ..	4
Button repeaters	6

To Correspondents.

*** Duly authenticated contributions, theoretical and practical, on every subject identified with the interests of which "The Telegraphic Journal" is the organ, will always command attention. Anonymous correspondence will be wholly disregarded. Literary communications and books for review should be addressed to the Editor; business communications to the Publisher

A Correspondent writes from Falmouth—"I should be glad if you would kindly inform me, in the next number of the Telegraphic Journal, whether the neutral line of a bar magnet remains in the same place, after a piece or pieces of soft iron have been placed in contact with it, as it was before the iron was put into contact with it. I find, in some books, that the pieces of iron become part and parcel of the magnet; if so, would not the neutral line be altered? In others the writers say the pieces of iron become polarised, each having a North and South pole."

[The pieces of iron certainly do not become part and parcel of the magnet; they each possess a North and South Pole; but whether the position of the neutral line is altered we cannot answer, and we should be glad if some correspondent would examine the point experimentally.—Ed. T. J.]

D. S.—The book is in the press, but will not be out for two or three months. The retail price of Weinhold's book is 31s. 6d.

Mr. Macdona does not seem to be aware that the Alphabetical Instrument is very largely adopted in England, and especially by private individuals. His instrument would be far more complicated and xpensive than those n use. There is nothing novel in his idea.

THE TELEGRAPHIC JOURNAL.

VOL. III.—No. 52.

ELECTRICAL TERMS.

THE great inconvenience that has hitherto existed in the electrical world, from the use of different terms to express the same idea by different writers, is fast dying out, owing principally to the influence of the action of the British Association, and their excellent reports upon electrical standards. There are four chief ideas involved in the consideration of electrical phenomena. These are expressed generally by *Potential*, *Quantity*, *Resistance*, and *Current*. The first has well-nigh jostled out of existence the indefinite and ambiguous word *tension*, and, what was frequently used for it, *intensity*. The second expresses a definite and clear idea of the magnitude or amount of electricity present. The third, the reciprocal, or inverse of conductivity —a term so little used because so little wanted— admits of no ambiguity or indistinctness. But the fourth still labours under the difficulty of having its various stages of relative magnitude interpreted sometimes by intensity of current, sometimes by strength of current, and sometimes by quantity of current. The last term is that still greatly used by telegraph engineers; the middle term is that introduced by the British Association, and gradually creeping into very general use among practical electricians; while the first term is very prevalent among our professors, and particularly those of the "foreign" school. The great objection to the use of the term "intensity," to imply the magnitude of the ratio $\frac{E}{R}$, is that until very recently the term was employed very largely to imply the magnitude of E; or, in other words, the difference of potential that determined the current. It is still so used in most of our text-books, and thus the use of such a term for another purpose introduces a difficultyin the minds of students which is very difficult to eradicate. The ease with which a science is mastered depends very greatly on the clearness with which terms are defined and comprehended. In Ohm's law—

$$C=\frac{E}{R}$$

if intensity is sometimes used to express the value of C and sometimes that of E confusion and difficulty must arise. If we were suddenly to introduce an entire new nomenclature into electrical science, none having previously existed, we might probably, without inconvenience, express the value of a current, by the term intensity; but when this word intensity from time immemorial, has been used to express the value of one of the conditions that determine the current, and when we find it so used by Daniel, Faraday, Snow Harris, and all our leading authorities, it is asking too much to give it an entire new meaning. It would be the same as though a new mathematical school were to spring up, and to call that which our fathers called a tangent a sine. The only argument in favour of its use, is that "intensité" is in universal use in French works. We might, with equal propriety, call a cabbage a shoe (choux).

Sir W. Thomson, our greatest living authority on Electricity, who formerly occasionally used "intensity," has long since abandoned that term in favour of "strength;" and, generally, our practical electricians have now abandoned intensity and quantity, and only speak of the strength of the current to indicate how one current differs from another in magnitude.

THE HELIOGRAPH OF MR. MANCE.*

By C. BECKER.

THROUGH the general introduction of Electric Telegraphy, and the all but universal adoption of the Morse alphabet, it occurred to Mr. Mance—who has the advantage of a thorough knowledge of both, and the privilege, if it can be called one, of a long residence in a country with plenty of sunshine—to develope and improve the existing appliances into a system. His aim has been to produce an instrument which is very compact, very portable, easily set up, and easily worked. Although he was first in favour of larger instruments (which are still preferable for permanent stations), he is now convinced that an instrument of the size here shown is all that is requisite. The chief objection to the adoption of the sun-telegraph is, that we cannot command the sun to shine in the same manner that we can control a galvanic battery; and it must be understood that Mr. Mance advocates his system only as an auxiliary to other systems of field telegraphy. It would come into operation at distances when other methods are useless or tediously slow, and it compares favourably with existing systems of signalling in cheapness, range, rapidity of communication, and, last, in portability. The flashes are invisible to any one placed far to the right or left of the direct line, so that, from elevated points, far distant communications could be kept up with a fortress without the besiegers having any suspicion of the fact.

It would be superfluous to give instances, when within the last few years the use of these instruments might have brought about the most important results.

The instrument consists of a light, but firm, tripod-stand, similar to those used for prismatic compasses. On the top a plate is moved by a tangent-screw which admits of quick and slow motion, and the plate carries on a pin a semicircular

* Read before the Society of Telegraph Engineers.

ring, which again carries on pivots the round mirror, the silvering of which is removed in the centre for the space of a circle about 3-16th inch diameter. To the plate is also attached a simple key, which is pressed down and springs back like an ordinary Morse key. This key is connected with the top rim of the mirror by a steel rod, which can be lengthened and shortened—as occasion may require—by turning the handle and screwing the rod through the small brass ball which secures it to the edge of the mirror.

By means of the last-named adjustment and the tangent-screw the glass can be altered, as the ever-changing position of the sun may require.

From 12 to 15 yards in front of the instrument is placed a sighting-rod. This rod is to mark a spot exactly in a line with the centre of the heliograph and the distant station. A metal stud marks the spot, and a wooden cross-piece marks where the flash rests when not directed on the opposite station.

The instrument can be set up ready for working in a few minutes. When the exact position of the distant station is not known, a flash of sunlight must be thrown in the direction of the most likely points, and this must be continued till it is answered by a flash, which indicates that a distant signalling party is on the look-out. Then, after releasing the tangent-screw, the glass must be turned to a convenient angle, and the sighting-stick must be directed in a line with the distant station by looking through the small aperture in the centre of the mirror. When this is effected, the stud must be raised or lowered till it is in the line of vision on a level with the centre of the glass and the distant flash, and the short cross-piece must be placed at right angles to the upright, about a foot below the stud. After being thus adjusted the instrument must not be moved.

The spot will be observed gradually to rise or fall, according to the direction in which the sun is apparently moving. The handle of the key, or the tangent-screw, or both, as the case may be, must be turned slightly after every two or three words, to ensure, as far as possible, that the centre of the spot shall be on the stud when the key is pressed down.

When the sun is rather low in the heavens, and behind the signaller, it becomes more difficult to direct the flash with accuracy. In consequence of the obtuseness of the angle the spot loses its circular form, and becomes rather dim when reflected on the stick. If it is required to work frequently with the sun in this position, the employment of a second glass on a light tripod stand is recommended.

But it would be useless here to enter more into the minutiæ of working the instrument: suffice it to say that, in experienced hands, twelve words and more per minute have been obtained, while others state that men—after a fortnight's practice—could attain only from four to five words per minute. As to the distance, 10 and 20 miles—and in very clear weather 40 miles—have been obtained.

A number of officers of the Indian Army have tried and reported upon the instrument, and—with the exception of one—all report most favourably of the system as an auxiliary to existing systems, and efforts are being made at the present moment to ensure their adoption for the Indian Service by the authorities.

ELECTRO-DEPOSITION OF METALS.

By J. T. SPRAGUE.

Arrangement of Objects.—This includes the consideration of several distinct conditions:—(1.) The position, horizontal or vertical. (2.) The relative proportions of objects and anode. (3.) The distances to be maintained. I propose to illustrate each of these by experiments, which the learner should study on the small scale, with a galvanometer in circuit, to show the actions set up.

Position.—Place a pair of copper strips, at least 4 inches in length, vertically in a small vessel, and pass a small current, leaving the experiment to go on quietly for a few days. It will be found that the anode is eaten away most at the top, and it will probably be cut through at the line of surface of the liquid. The cathode, on the contrary, will have a thick coating at the bottom and little at the top. There will be a thick edging of hard nodules, and the lower corners will bulge out. Probably also, the whole surface will be marked with vertical lines, commencing in a spot, like a prolonged note of exclamation (!). Now repeat this experiment in a vessel with a porous partition having little porosity, or in two vessels connected with a syphon or a piece of cotton wick, using a nearly saturated solution of copper sulphate without acid in the anode cell. The anode will soon be covered with crystals of sulphate of copper, and the previously noted conditions will be exaggerated at the cathode. The cause of these actions is, that as the copper is dissolved at the anode a denser solution forms, which sinks and leaves acid—when present—above; or, if the solution is saturated, the newly-formed salt cannot dissolve, and crystallises where it forms. At the cathode, copper is removed from the solution, which becoming lighter, rises in a thin stream along the face, thus having less and less copper in contact with the plate.

Circulating Currents.—Now take a thin glass beaker, containing water and some powder of about equal density with water, and hold one side over a Bunsen's burner. That side will become hot, and a stream of water will flow upwards along it, flowing over the surface, descending along the cool side, and returning along the bottom. This circulating current is due to the different specific gravities of hot and cold water, and exactly resembles the conditions set up by the same cause in the depositing vessel. There we have a stream of lighter liquid running up the cathode, and of heavier solution flowing down the anode, and producing a continuation of these currents in the upper and lower strata. But the upper current is rendered acid by losing metal at the cathode, and is therefore very active where it first reaches the anode at its *upper* part: in like manner the lower stratum, having passed over the face of the anode, is highly charged with metal, and is in turn specially active where it reaches the *lower* edge of the cathode: in consequence of these two conditions an electromotive force is set up within the liquid, in a diagonal line, between these two active parts, which aids the ordinary or working current, and concentrates the action upon these parts. Most writers attribute the effect to *stratification* of the liquid, but it is the *circulating current* which does the mischief, and it is also the cause of the lines and spots: the slightest irregularity upon the surface deflects the upward flowing

current, and the obstruction constantly grows as it receives more and more of the metal brought to it by the impinging current, while the hollows are filled with weaker solution, which cannot supply so much metal.

Horizontal Arrangement.—Arrange two equal-sized plates in a deep vessel charged with a good solution, one being near the surface of the liquid, and the other near the bottom, and connect the zinc of the battery to the upper plate, making this the cathode, and allow a full current to pass for some time. If the vessel is transparent, actions similar to those just described will soon become apparent; the solution just under the upper plate will become pale in colour, the deposit forming will pass into the sandy condition, and the resistance of the liquid will increase, and eventually the plate will be found coated with bubbles of hydrogen. All these effects are due to the removal of metal from the solutions making the upper stratum the lightest, so that no mixture or circulation is produced, and from the opposite reason a dense solution—or even a deposit of crystals—forms at the lower plate. Now repeat this arrangement, but making the upper plate the anode, and observe the different result produced: the solution just below the upper plate deepens in colour, and may be seen descending through the liquid, while on the lower plate a perfectly regular uniform coat of metal, in its best condition, is steadily deposited.

It is evident, therefore, that this latter arrangement is by far the best for plates of large size, and more especially for deeply-cut medallions: it has, however, the drawback of permitting any dirt, &c., in the solution to deposit on the face of the objects, which of course interferes with regular deposit and also injures its quality: whenever such an arrangement is adopted, it is essential therefore to keep the solution very pure, by filtration, covers, &c., and it is well to use a porous division to catch any particles falling from the anode. Such a division is very readily formed of a slight wooden frame paraffined, with a cover of muslin stretched upon it, upon the surface of which a sheet of filtering- or blotting-paper can be secured: this filters the descending liquid and catches any solid particles, while its resistance is very slight.

Vertical arrangement is, however, most commonly employed, because it is most convenient: to secure a good deposit it is necessary occasionally to change the position of the objects, so as to average the irregular actions; if possible, these changes should be made without removal from the solution or break of connection, but if removal is requisite the same precautions to secure cleanliness should be observed as at the first immersion: in copper this is best effected by a momentary dip into acid at the time of replacing, and so with the suitable liquids for other metals. When striæ or nodules are seen to be forming they should, if possible, be removed by filing, burnishing, &c., before the completion of the deposit.

Proportions of Objects and Anode.—This is of consequence only so far as they may affect the conditions of working: generally it is well to have nearly the same surface area in both. The real point to be attended to is to secure, so far as possible, that all the parts of the object shall have some portion of the anode at equal distance from them, in order to maintain equality of resistance at all points, except where a less or greater thickness or rate of deposit is required.

Distance between Objects and Anode.—Use a large plate to receive a deposit, and place a very small anode close to and opposite to the middle, and pass a considerable current: it will be found that the deposit will be thick in the centre, thinning away to nothing at the edges; the thickness of deposit will, in fact, be in the opposite proportions to the distance between each point and the nearest part of the anode. Therefore the anode should be so arranged, as to form and distance, as to secure equal distances across the liquid to all parts of the object. With a regularly formed object with smooth surfaces the two may be close together, in order to diminish resistance; but irregular objects—and more especially any with portions deeply chased or undercut—require a greater distance: for suppose such a recess to be ¼ inch deep, at a distance of 1 inch this represents a quarter of the distance, and the relative deposit on the face and in the deep part would be as 5 to 4, but if the distance were 3 inches the difference would be only as 13 to 12. Such objects also require to be worked with a lower "density of current,"—that is to say, taking a longer time for a given thickness, in order to allow the liquid in the hollows to replace itself by diffusion as its metal is exhausted, a consideration of even more practical influence on the actual resistance between the several points than the mere lineal distance.

THE ROYAL INSTITUTION.

Notes of a Course of Seven Lectures on Electricity.
By Professor Tyndall, LL.D., F.R.S.

February—March, 1875.

Notes of Lecture III. *February* 18, 1875.

(Continued from page 5.)

1. The next discovery throws all former ones into the shade. It was first announced in a letter addressed on the 4th of November, 1745, to Dr. Lieberkühn, of Berlin, by Kleist, an ecclesiastic of Cammin, in Pomerania. He fastened a nail in a phial into which he had poured a little mercury or spirits. On electrifying the nail he could pass from one room to another with the phial in his hand and ignite spirits of wine with it. "If," says he, "while it is electrifying I put my finger, or a piece of gold which I hold in my hand, to the nail, I receive a shock which stuns my arms and shoulders."

2. In the following year Cunæus of Leyden made substantially the same experiment. It caused great wonder and dread, which arose chiefly from the excited imagination. Musschenbroek felt the shock, and declared in a letter to a friend that he would not take a second for the crown of France. Bleeding at the nose, ardent fever, a heaviness of head which endured for days, were all ascribed to the shock. Boze wished that he might die of it, so that he might enjoy the honour of having his death chronicled in the Paris Academy of Sciences. The Leyden philosophers stated the conditions necessary to the success of the experiment, and hence the phial received the name of the Leyden phial, or Leyden jar.

3. The discovery of Kleist and Cunæus excited the most profound interest, and the subject was ex-

plored in various directions. Wilson in 1746 filled a phial partially with water, and plunged it into water, so as to bring the water surfaces within and without to the same level. On charging such a phial the strength of the shock was found greater than it had been before.

4. Two years subsequently Dr. Watson and Dr. Bevis noticed how the charge increased as the area of the non-electric in contact with the outer surface increased. They substituted shot for water inside the jar, and obtained substantially the same effect. Dr. Bevis then coated a plate of glass on both sides with silver foil, within about an inch of the edge, and obtained from it discharges as strong as those obtained from a phial containing half a pint of water. Finally Dr. Watson coated his phial inside and out with silver foil.

By these steps the Leyden jar reached the form which it possesses to-day.

5. The physiological effect of the shock was variously studied. Graham caused a number of persons to lay hold of the same metal plate, which was connected with the outer coating of the charged jar, and also to lay hold of a rod by which the jar was discharged. The shock divided itself equally among them.

6. The Abbé Nollet formed a line of one hundred and eighty guardsmen, and sent the discharge through them all. He also killed sparrows and fishes by the shock. The analogy of these effects with those produced by thunder and lightning could not escape attention, nor fail to stimulate inquiry.

7. Franklin was twice struck senseless by the shock. He afterwards sent the discharge of two large jars through six robust men; they fell to the ground and got up again without knowing what had happened; they neither heard nor felt the discharge. Priestley, who made many valuable contributions to electricity, received the charge of two jars, but did not find it painful. This experience agrees with my own. In the theatre of the Royal Institution, and in the presence of an audience, I once received the discharge of a battery of fifteen jars. Unlike Franklin's six men, I did not fall, but like them I felt nothing. I was simply extinguished for a sensible interval.

8. This may be regarded as an experimental proof that people killed by lightning suffer no pain.

9. Franklin held electricity to be a single subtle fluid; electrified bodies he thought possessed either more or less than their natural share of this fluid. Hence the terms *plus* and *minus*, *positive* and *negative*, as applied to electricity. His notion of the Leyden jar was, that whatever might be the quantity of "electric fire" thrown into the jar, an equal quantity was dislodged from the outside. The two coatings of the jar were therefore in opposite electrical conditions. These theoretic views led Franklin to the formation of his "cascade battery."

10. Franklin sought to determine the *seat* of the charge in the Leyden jar. He charged a bottle containing water: dipping a finger into the water and touching the outside coating he received the shock. He was thus led to inquire, Is the electricity in the water? He poured the water into a second bottle and found that it carried no electricity along with it.

11. "He then judged that the electric fire must either have been lost in the decanting, or must remain in the bottle; and the latter he found to be true, for filling the charged bottle with fresh water he found the shock, and was satisfied that the power of giving it resided in the glass itself."* An account of Franklin's discoveries was given by himself in a series of letters addressed to Peter Collinson, Esq., F.R.S., from 1747 to 1754.

12. By rendering the coatings of the Leyden jar movable the jar may be charged, the interior coating removed, placed on the ground, and proved unelectric. The jar may then be removed from the outer coating and the latter proved unelectric. Restoring the jar and coatings, on connecting the two latter, the discharge passes in a brilliant spark.

13. As experimental knowledge increased thought became more definite and exact as regards the relation of these electrical effects to thunder and lightning. The Abbé Nollet thus quaintly expresses himself: "If anyone should take upon him to prove, from a well-connected comparison of phenomena, that thunder is, in the hands of nature, what electricity is in ours, and that the wonders which we now exhibit at our pleasure are little imitations of those great effects which frighten us, I avow that this idea, if it was well supported, would give me a great deal of pleasure." He then points out the analogies between both, and continues thus: "All those points of analogy, which I have been some time meditating, begin to make me believe that one might, by taking electricity as the model, form to one's self in relation to thunder and lightning, more perfect and more probable ideas than what have been offered hitherto."†

14. These views were prevalent at this time, and out of them grew the experimental proof by Franklin of the substantial identity of the lightning flash and the electric spark.

15. But before entering further on the facts of electricity, it will be well to seek some theoretic guidance. The insufficiency of the facts of observation to appease the desires of the mind has been already mentioned. In the midst of facts we long for principles to connect them, and to present them in their proper relations.

16. Accordingly, side by side with the phenomena hitherto illustrated there ran a vein of speculation, more or less vague, as to the nature of electricity itself. In thus speculating we quit the field of observation, and draw upon the constructive imagination, which, guided by existing knowledge, forms the physical principle, and commits it to the process of experimental deduction to test its sufficiency and truth.

17. Thus, in relation to electricity, Boyle had his unctuous effluvia, Newton his ether, Du Fay his vitreous and resinous electricity, Nollet his affluences for repulsion, and his effluences for attraction, Franklin his single electric fluid, and, finally, Symmer his theory of two electric fluids.

18. The simplicity of Franklin's theory of a single electric fluid is only apparent. It involves consequences of a very doubtful kind. In accounting by it for the mutual repulsion of negatively electrified bodies, we are driven to the assumption that ordinary matter is self-repulsive.

19. The theory of two fluids is by far the most convenient. Still, though it is a principle of ex-

* Priestley's "History of Electricity," 3rd edition, p. 149.
† Priestley's "History of Electricity," pp. 151—52.

treme simplicity, and of great power in uniting electrical phenomena, it is to be regarded rather as an image of the mind than as a physical reality.

20. According to this theory, electrical phenomena arise from the action of two fluids, each self-repulsive, but both mutually attractive. Every body in its natural condition possesses both fluids in equal quantities. As long as the fluids are mixed together they neutralise each other; the body in which they are thus mixed being in its natural or unelectric condition.

21. By friction, and various other means, the two fluids are torn asunder; the one clinging by preference to the rubber, the other to the body rubbed.

22. As a matter of fact the rubber and the body rubbed are always oppositely electrified.

23. When smooth glass is rubbed with silk the glass is electrified positively and the silk negatively. When sealing-wax is rubbed with flannel the wax is electrified negatively and the flannel positively.

24. These terms are adopted purely for the sake of convenience. There is no reason in nature why the resinous electricity should not be called positive, and the vitreous electricity negative. Once agreed, however, to apply the terms as fixed in (23) we must adhere to this agreement throughout.

25. When electricity is communicated to a conductor it distributes itself over the surface; but the mode of its distribution depends upon the form of the conductor.

26. On an insulated sphere it distributes itself equally all over the surface. Riess expresses this by saying that the electric *density* is the same at all points of an electrified spherical conductor.

27. But this is only true of a sphere. If the conductor be elongated, the electricity is densest at the ends. If it be a cone, different electric densities are observed at the apex and base of the cone, and on the conical surface. Were the cone *perfectly* sharp—if the apex ended in a mathematical point, the theoretic density would be infinite. No electricity whatever could exist on such a pointed body; it would be instantly diffused through the air.

28. The more perfect the point of an electrified body, the greater will be the electric density, and the greater the tendency to diffusion. By determining the electric density Riess finds the thorn of the euphorbia sharper than an English sewing-needle, which, however, excels in sharpness the thorns of the gooseberry, the cactus, and the rose.

29. It is the intense electrification of the air at a point and its consequent repulsion that produces the electric wind. It is the escape of the electricity from a point which renders the charging of a conductor on which a needle, or other pointed body, is placed, difficult: it is the copious outflow of electricity which renders it possible by means of a point to convey electricity to bodies at a distance.

30. We have now to apply the theory of electric fluids to the important subject of electric *induction*.

31. It was noticed by early observers that *contact* was not necessary to electrical excitement. Stephen Gray, for example, by bringing his excited glass tube near one end of a conductor, attracted light bodies at the other end. Canton, in 1753, suspended pith-balls by thread, and holding an excited glass tube, at a considerable distance, caused them to diverge. On removing the tube the balls fell together, no permanent charge being imparted to them. Such phenomena were further developed by Wilcke and Æpinus; while Coulomb's measurements and Poisson's calculations extended and defined our knowledge of the subject.

32. These and all similar results are embraced by the law, that when an electrified body is brought near an unelectrified one, the neutral fluid of the latter is decomposed; one of its constituents being attracted, the other repelled. When the electrified body is withdrawn, the separated electricities flow again together and render the body unelectric.

33. This decomposition of the neutral fluid by the mere presence of an electrified body is called *induction*. It is also called electrification by *influence*.

34. If, while it is under the influence of the electrified body, the influenced body be touched, the free electricity (which is always of the same kind as that of the influencing body) passes away, the opposite electricity being held captive.

35. On removing the electrified body the captive electricity is set free, the conductor being charged with electricity opposite in kind to that of the body which electrified it.

36. Numberless other experiments are suggested and explained by the principle of induction. It explains why neutral bodies are attracted by electrified bodies. In reality the bodies attracted are *not* neutral: they are electrified by influence; and it is in virtue of their being thus electrified that they are attracted.

37. It explains the "discharge" of an electrified conductor by a point. For the induced electricity becomes so dense upon the point that it streams out against the inducing body and rapidly neutralises it.

38. It explains the fact that when a point upon an insulated conductor is turned towards an electrified body, the conductor charges itself with the same electricity; and that when the point is turned away from the electrified body the conductor charges itself with the opposite electricity. In the first case the unlike electricity is *drawn* away by attraction; in the second case the like electricity is *driven* away by repulsion.

39. It explains the first approach and subsequent retreat of the gold leaf noticed by Du Fay. For the edges and corners of the leaf, acting like points, discharge the opposite electricity against the influencing body. The leaf being thus rapidly charged with electricity of the same kind as that of the influencing body, repulsion is the consequence.

40. There is also a discharge of the electricity similar to that of the influencing body from the more distant portions of the leaf, to which that electricity is repelled. Both discharges are accompanied by an electric wind. It is possible to give the gold leaf a shape which shall enable it to float securely in the air by the reaction of the two winds issuing from its opposite ends.

41. Well-pointed lightning conductors when acted on by a thunder cloud behave in the same way. The opposite electricity streams out from them against the cloud.

42. Franklin saw this with great clearness, and illustrated it with great ingenuity. The under side of a thunder cloud when viewed horizontally, he

observed to be ragged, composed of fragments one below the other, and sometimes reaching near the earth. These he regarded as so many stepping-stones which assist in conducting the stroke of the cloud. To represent these by experiment he took two or three locks of fine loose cotton, tied them in a row, and hung them from his prime conductor. When this was excited the locks stretched downwards towards the earth; but by presenting a sharp point erect under the lowest bunch of cotton, it shrunk upwards to that above it, nor did the shrinking cease till all the locks had retreated to the prime conductor itself. "May not," says Franklin, "the small electrified clouds, whose equilibrium with the earth is so soon restored by the point, rise up to the main body, and by that means occasion so large a vacancy, that the grand cloud cannot strike in that place?"

Experiments in Lecture III.

(1.) Early forms of Leyden jar illustrated. A small phial, two-thirds filled with water, with a cork in the neck, and a nail long enough to reach the water through the cork; a similar phial two-thirds filled with shot. Clasping either phial with one hand, and charging it, a smart shock is experienced when the nail is touched with the other hand. In this and other experiments a rubbed glass tube suffices to charge the jar, though this is more rapidly done by the electrical machine.

(2.) Water in wide glass vessel; a second glass vessel immersed in the first, and filled to the same height with water. Outer water connected by a wire with the earth; inner water connected by a wire with the electric machine; one or two turns furnish a sufficient charge. Removing inner wire and dipping one finger into the outside, and the other into the inside water, a smart shock is experienced. Placing in the inner water a metal stem and knob, and charging strongly, a brilliant spark passes on connecting the earth-wire with the knob.

(3.) Glass jar coated (not too high) with tin-foil; filled to the same height with water, placed on india rubber cloth, and charged by connecting outside coating with the earth, and the water (by means of a cemented stem and knob) with an electric machine. Bright spark on discharging. Recharge. Taking hold of jar with india-rubber, pour water into second similar jar; no sensible charge imparted. Pour fresh water into first jar; retention of charge shown by brilliant spark. Edge of jar out of which water is poured to be surrounded by a band of bibulous paper to catch final drop.

Note:—"Carriers" formed of pieces of copper-paper with shell-lac, or ebonite handles, are very useful.

(4.) Jar with movable coatings charged. Touch knob with carrier—it attracts lath balanced on egg. Remove inner coating and place it on table; the small amount of electricity which it carried away is thus discharged, and the knob now shows no power of attraction. Remove glass vessel; the outer coating is also found neutral. Restore glass and inner coating; lath immediately attracted by carrier which has touched restored knob. Discharge jar: a brilliant spark.

(5.) Glass plate 9 inches square; tin-foil on both sides 6 inches square. Connect one side with earth and the other with machine. Charge and discharge: a brilliant spark.

(6.) Ordinary Leyden jar; charged and discharged.

(7.) An elongated metal conductor, or one formed by coating wooden roller with tin-foil, is supported on warm glasses or by a glass pillar: small weight suspended by silk ribbon placed on one end: excited glass tube placed over the other end. Weight now removed is charged with electricity and attracts lath. This is the experiment of Æpinus.

(8.) Sphere of wood coated with tin-foil: placed on warm tumbler: excited glass tube brought near: touch distant part of sphere with carrier: it attracts lath. Touch surface adjacent to excited tube, it also attracts lath. The first charge repels excited glass needle, and is therefore positive: the second repels excited gutta-percha, and is therefore negative. One of these charges, moreover, neutralises the other in the gold-leaf electroscope.

(9.) While the glass tube is near the sphere, touch the latter anywhere with the finger, then touch distant part of sphere with carrier: no action. Now remove glass tube and touch again with carrier: strong action. The electricity liberated by the removal of the tube proves to be negative.

(10.) Two insulated spheres are caused to touch; excited glass rod is held near one of them and they are then separated. The one is now charged with positive, the other with negative, electricity.

(11.) I stand on an insulating stool: present the right hand to the balanced lath, and stretch out the left arm. An assistant brings excited glass tube over that arm, lath immediately follows hand.

(12.) I touch the lath and all "virtue" disappears (the lath is not insulated). After this, as long as the excited tube is held over the arm there is no attraction: on its removal attractive power is restored. Here the first attraction was by positive electricity driven to the hand, and the second by negative electricity, liberated by the removal of the glass rod. The one repels rubbed glass, the other repels rubbed gutta-percha; and on charging the electroscope with both they neutralise each other.

(13.) I stand on insulating stool, and place the right hand on electroscope: no action. I stretch forth the left arm and permit an assistant alternately to bring near, and to withdraw, an excited glass tube. The gold leaves open and collapse in similar alternation. At every approach positive electricity is driven over the gold leaves; at every withdrawal the equilibrium is restored.

(14.) In all cases the rubber, whether it be of silk or of flannel, attracts balanced lath. The silk rubber repels rubbed gutta-percha, and is therefore negative; the flannel rubber repels rubbed glass, and is therefore positive. Laying silk rubber on electroscope, leaves diverge. Laying flannel rubber on silk one, leaves close again; the one rubber neutralises the other, and each of them in relation to the body it has rubbed is oppositely electrified.

(To be continued).

THE BOAT RACE.

Rowed for the first time in 1829, over the course at Henley-on-Thames, the Oxford and Cambridge Universities Boat Race has increased steadily in public favour until it has become as genuine an institution as the Derby, or the Cup day at Ascot. Not for some years, however, did it take its

place as an annual fixture; for we find that between 1829 and 1836 there was no race, and that down to the year 1856 the event was several times intermitted. From 1836 until 1842 the race was rowed from Westminster to Putney; between 1842 and 1845 there was no race, and in the latter year the course was changed to that now rowed over—viz., from Putney to Mortlake. Once or twice, down to the year 1863, the course was reversed, and the boats steered down the river from Mortlake to Putney; but from 1864 onwards the course has been that which has become familiar to the whole of London—we had almost said to the whole country. In all, the race has been rowed 32 times during the 45 years it has been in existence; and Oxford has been successful 17 times against 15 victories scored for the sister University. Latterly, the victories have gone in cycles, Oxford having won during the nine successive years between 1861 and 1869 inclusive; and Cambridge having scored five victories in succession down to last year. Whether the result of this year's race, which took place last Saturday week, is an indication that the tide has turned once more in favour of the Isis, as against the Cam, time alone will reveal. But time can scarcely alter, otherwise than to intensify the interest which is manifested year after year in the great aquatic event of the time—the "blue riband" of the Thames. When the race was rowed over the picturesque course at Henley 45 years ago, the distance was only 2¼ miles; yet the time occupied was 14½ minutes, and over this short distance Oxford is recorded as having been victorious by "many lengths." The course from Putney to Mortlake is slightly over 4 miles, and it is interesting to note how the speed of the rowing has increased with the lapse of years since the race was first inaugurated. During the past five years, the *average* duration of the race has been 21 min. 44 sec. But in 1873, when sliding seats were used for the first time, the time occupied in covering the 4 miles was only 19 min. 35 sec., or about 5 minutes longer than was occupied at Henley in covering little more than half the distance. The course between Putney and Mortlake may be almost described as classic ground. Its landmarks are as well-known as those of the most frequented thoroughfares in London; and the mere mention of the "Soap Works," "Biffen's," the "Oil Mills," "Chiswick Eyot," "Corney Reach," "Barnes Bridge," or the "Ship," is enough to conjure up all the scenes of the exciting contest, and to suggest minute calculations as to the number of lengths ahead.

But besides being a great gala, the boat race is an event in our telegraphic annals not to be altogether despised. Not that it dates back a very long way in this respect; for although the wires are now carried to the water's edge at Henley on the occasion of the annual regatta at that picturesque little town, it is to be feared that no such "facilities" existed in connection with the first University Boat Race held there 45 years ago. Indeed, the telegraph had hardly been thought of at that time; and it was almost 10 years later that Cooke and Wheatstone took out their first patent for our dear old friend, the "Double Needle." It is doubtful whether, prior to the transfer of the telegraphs to the Post Office, any special efforts were put forth to stimulate telegraphy in connection with the event. But it is quite certain that immediately after the transfer, the opportunity was seized upon to bring grist to the mill of the ever-going-round postal system. In 1871, a temporary office was opened on the Boat Race day, under the stand adjoining the "Ship" at Mortlake; but the result appears to have been only indifferent, as no record was kept of it. In 1872, the matter was taken in hand by the Special Arrangements Branch of the Telegraph Department; and the completion in that year of the Travelling Telegraph Office enabled a fair trial to be made at Mortlake. As many as 357 messages, of the value of £19, resulted from the operations there and at Putney; and it became clear that a business was to be done with improved arrangements and increased wire accommodation. In 1873, the smaller telegraph-carriage was stationed at Putney, adjoining the "Star and Garter," so that temporary offices were established at the start as well as at the finish of the race; and what with this, and the increase of facilities at Hammersmith, Barnes, and other intermediate points, the number of messages suddenly rose to 698. In 1874, the arrangements were of a somewhat similar character, but no very marked increase of business resulted in that year, the number of messages being only 723. Last Saturday week, however, a very decided improvement was effected in the telegraphic arrangements. Carriages were stationed at Putney, Hammersmith Bridge, and Mortlake, each having direct and independent communication with the central station, and monopolising amongst them no fewer than five wires—viz., two at Mortlake, two at Hammersmith, and one at Putney. The start was exhibited at Hammersmith and Mortlake, and the finish at Hammersmith and Putney, within 10 secs. after each event; and the result of the race must have been known at Putney at least a quarter of an hour before it could possibly have been known under previous arrangements. The natural result of this enterprise on the part of the Post Office was to largely increase the amount of telegraph business transacted as compared with that of former years. Upwards of 1000 messages, and more than three columns of news for the press, were transmitted in connection with the event, and by far the largest proportion of this work was disposed of in the temporary offices stationed along the river side. At Hammersmith, the experiment of opening a temporary office adjoining the Bridge House was so successful, that 120 messages were handed in within a few minutes after the result of the race was known: while, at Mortlake, no fewer than 310 messages were disposed of within about two hours after the race was over. At the Post Offices at Putney, Hammersmith, and Barnes, a considerable increase of telegraphing was experienced in connection with the event of the day, and altogether 1040 messages resulted from the operations which we have thus minutely described. It would be a mistake to suppose that the interest in the Boat Race is purely local, or even British, for we understand that no fewer than 20 telegrams were forwarded to the Continent and elsewhere abroad in connection with the event.

A curious development of telegraphic business relating to the Boat Race is to be found in the operations of press correspondents conducted by means of the wires. One would imagine that the

proximity to London of the scene of action would render newspaper telegraphing altogether unnecessary; but this is not so. For days prior to the race, the evening papers have regularly appeared with the heading, "Latest from Putney;" and on the morning of the eventful day, every movement of the crews, down to the very second at which the start is effected, and the fact of which boat catches the water first, is religiously wired at frequent intervals to Fleet Street and the Strand. The result, of course, is telegraphed everywhere—even to distant Bombay and more distant Melbourne—and the rapidity with which this was effected last Saturday week may be imagined from the fact that the *Standard* newspaper was on sale in Fleet Street within one minute after the race was finished at Mortlake. One enterprising news agency has made all sorts of efforts to keep its subscribers advised of the progress of the race from point to point, even to the paying out of a wire from the stern of one of the accompanying steamers, and the laying of a cable beforehand along the bed of the river. But under the improved arrangements made by the Post Office this year, nothing of the kind was attempted, and before another year it is hoped that still further improvements will be carried out.

Notes.

ELECTRIC SCIENCE occupies a place of no mean importance in the new Opera House in Paris. A special room is set apart as a battery room, in which 360 Bunsen's cells, arranged in sets of 60 on rough plate-glass tables, are manipulated to pass a current in any part of the stage so as to direct the electric light upon any point of the scenery. The sunlight and startling effects produced by French scenists are really beautiful. The rainbow in Mosé is wonderful.

The Tale of a Rat in our last number recalls a somewhat different tale of a mouse, which happened on the sea-wall near Dawlish, where the wires (gutta-percha) are carried in grooved boarding. Periodical contacts of short duration were observed, which were totally independent of any change in the weather. They were found to be due to the effect of the calls of nature of a mouse, who had made her nest, reared her progeny among the wires, and partially devoured their insulating protection.

Our contemporary, *Nature*, has commenced a series of articles on "The Progress of the Telegraph," from which our readers will be surprised to learn that "up to 1844 electrical knowledge was more or less confined to the lecture table; *crude* experiments upon frictional electricity, and the elements of magnetic and voltaic phenomena, constituted the portfolio of knowledge as accepted by the public," and that little or no progress was made until "In 1848 Holmes gave to telegraphy the practical result of his researches as regards the rapid transmission of signals over extended circuits!" The name of Sir William Cooke—the father of the English telegraph system—is scarcely mentioned! and inductive capacity and absorption are said to be the same thing!!

Proceedings of Societies.

SOCIETY OF TELEGRAPH ENGINEERS.

THE Annual General Meeting was held on the 9th December, 1874. Mr. LATIMER CLARK, Vice-President, in the chair. The annual report was read, and the ballot for President and Council took place, with the result of which our readers are well acquainted. Later in the evening, Lieut. JEKYLL, R.N., read an interesting paper on the "*Telegraph in the Ashantee War*," describing many interesting details as to the difficulties of constructing a line of telegraph through a country so heavily covered with wood and undergrowth. The difficulty was enhanced by the unhealthy nature of the climate, which also increased that of signalling. Bamboos were used as poles, with insulators fastened into the top. The telegraph answered perfectly for all the various requirements of the war.

In the discussion which followed, the question again turned on the relative merits of "sound" versus "record" for instruments for military purposes; it was noticed on this occasion that gentlemen who were formerly in favour of a record were now most decidedly in favour of sound.

The value of the telegraph in connection with warfare was still further exemplified by the military speakers, and cordial recognition was made of the assistance rendered by the Postal Telegraph Department in supplying stores with remarkable celerity.

At this meeting 50 candidates were elected, thus bringing up the total number of all classes of members to 645.

THE Ordinary Meeting was held on the 13th January, 1875. Mr. LATIMER CLARK, President, in the chair.

The PRESIDENT delivered his inaugural address, which has appeared *in extenso* in these columns.

THE Ordinary General Meeting was held on the 27th January, Professor FOSTER, F.R.S., in the chair.

A paper was read by Mr. C. BECKER on "*The Heliographs of Mr. Henry Mance.*" (See p. 73.)

Subsequently a paper was read from Mr. GRAVES, of Valentia, "*On Vibrations due to Earth Plates.*"

Mr. GRAVES called attention to the great difficulties experienced in the early working of the Atlantic Cable by vibration of the spot of light of the mirror instrument, which ultimately were found due to the polarisation of the earth-plates. The various earths had been arranged in the most systematical order, with the object of serving the several cables without undue interference; but after repeated experiments, the earths were found to produce these vibrations, whatever combination was used; finally they were not got rid of until earth was actually made with the outside sheathing of the cable. As the earth-plates were separated from the office at great distances, the question became of some interest, and it was at length necessary to make earth for every cable on to its exterior sheathing. It, therefore, became necessary in providing for every new cable to provide also a companion earth wire from the office to the cable hut. Mr. Graves attributes the result to the partial insulation of the telegraph station and its locality from

he main land due to its peculiar geological formation.

In the discussion which followed, the effects stated by Mr. Graves were explained by Mr. Preece as due to the simple effect of polarisation of the various earth-plates, causing slight opposing currents to be constantly passing, and thus accounting for the slight but constant movements of the spot of light.

At the usual ballot, 23 candidates were admitted into the Society.

Notices of Books.

Exposé des Applications de l'Electricité. Par le Comte Th. du Moncel, Officier de la Légion d'Honneur et de l'Ordre de St. Wladimir de Russie; Ingénieur-Electricien de l'Administration des Lignes Télégraphiques Françaises. 3° Edition Entièrement Refondue. Paris. 1872.

This famous work of the Count du Moncel's is too little known amongst the majority of English physicists. It is more than its title indicates. For it contains an excellent outline of the theoretical part of dynamic electricity as well as the fullest and minutest details of the practical applications of this invaluable form of energy. With that indefatigable industry which is characteristic of the author, Count du Moncel has gathered into these volumes the majority of the innumerable modifications and improvements in electrical instruments that have been made in late years.

The surprising amount of fertility of invention that exists in various parts of the world is shown nowhere more strikingly than in the perpetually-recurring crop of new electrical devices, good, bad, and indifferent. Count du Moncel's experience has enabled him to select the most valuable of these inventions, and in many cases he gives the results of his own careful experiments made for the special purpose of testing their utility. French discoveries and improvements in electrical instruments naturally have the preponderance in these volumes, but ample justice is done to English science, nor have the chief additions made by other nations been neglected. The issue of a third edition has enabled M. Moncel to add to the value of his work by increasing the size and scope of the undertaking, so that he now gives us a complete theoretical as well as practical view of the science of electricity.

The first volume, of about 500 pages of small type, is devoted to what the author terms the "technology" of electricity. That is to say, all the technical knowledge that is necessary for the application of electric currents. Hence, in this volume, we have a capital *exposé* of Ohm's law and the practical deductions therefrom, a detailed examination of the various batteries—and their name is legion,—including a description of secondary batteries and earth batteries; then comes an excellent account of the British system of electrical units; and, finally, the practical methods adopted in electrical measurements, with the theory of each method very clearly stated. The second volume discusses the laws of electro-magnetism, and the best conditions for the construction of electro-magnets; then follows a description of the various electro-magnetic contrivances, and of the construction of induction apparatus; then a full account of the electrical apparatus employed in experimental inquiries; and the volume concludes with an explanation of the different systems employed in telegraphy. The third and fourth volumes, which are to follow, we have not yet received. The exhaustive manner in which the subject is handled in the first two volumes leads us to look forward with interest to the remaining parts of this invaluable work. Unquestionably, Count du Moncel has given to practical electricians one of the most important and useful works ever published on their special subject. The value of such a work as this to inventors as well as to students cannot be over-estimated, when one considers the loss of time and capital that yearly takes place from the re-discovery of instruments, or modifications of apparatus, against which loss such a *resumé* as this will most effectually guard.

We will now give our readers a few extracts of interest translated from the two volumes before us. Here is a method for amalgamating zincs that will everywhere be found useful, and which is new to us:—

"Several methods have been proposed for amalgamating zincs; but the simplest and quickest is that of M. Berjot (a chemist at Caen), which consists in immersing the zinc in a liquid composed of nitrate of mercury and hydrochloric acid. A few moments is sufficient for the complete amalgamation of the zinc, however soiled its surface may be. With a litre of this liquid, which costs less than two shillings, 150 zincs can be amalgamated. The liquid should be prepared in this manner:—Dissolve in warm water 200 grms. of mercury in 1000 grms. of aqua regia (nitric acid 1 part, hydrochloric acid 3 parts). When the mercury is dissolved, add 1000 grms. of hydrochloric acid."

In connection with this subject, the following preparation for amalgamating iron is very simple, although we cannot answer for its efficacy:—

"On carefully-cleaned iron, pour a solution of chloride of copper in hydrochloric acid; a thin coating of copper will be deposited. A solution of bichloride of mercury in hydrochloric acid is applied to this, and the surface is now thoroughly amalgamated."

In regard to the economical application of electricity, no subject is so important as the relative merits of different forms of batteries. For illuminating purposes and lecture demonstration we have hitherto had to rely upon the Bunsen or Grove battery. But, during the siege of Paris, a form of bichromate of potash battery, known as the "Chutaux" battery, was frequently employed to yield the electric light used on the ramparts. The author gives a full account of different forms of the Chutaux battery, and furnishes some interesting data for the comparison of the Chutaux and Bunsen battery when giving the electric light. The following results were obtained from the two batteries, each being composed of 48 cells, and each working for two hours:—

Bunsen's Battery.

Light equal to: At beginning.	End.	Mean.	Surface of Zinc employed.
109	66	87·5	49,428 c.c.
Carcel lamps.			

Chutaux Battery.

Light equal to: At beginning.	End.	Mean.	Surface of Zinc employed.
132	63	97·5	14,400 c.c.
Carcel lamps.			

In working each of these batteries, for half-an-hour successively, the following results were found:—

		Bunsen. (Light Equal to)	Chutaux. (Light Equal to)
1st period of half-an hour		109 Carcel lamps.	132 lamps.
2nd ditto	Beginning	134 lamps.	128 ,,
	End ..	137 ,,	100 ,,
3rd ditto	Beginning	106 ,,	80 ,,
	End ..	97 ,,	51 ,,
4th ditto	End ..	66 ,,	63 ,,

According to these figures, the bichromate of potash battery flags much quicker than the nitric acid battery, a fact which evidently depends on the polarisation of its plates, to which it is always liable. It is, however, more economical.

One rather important advantage of these batteries is that they can be kept in a closed place without giving out any odour or unhealthy emanation; besides this, the liquid evaporates slowly. The author had also been able to verify the statement that, after a battery had been charged for more than a year, and then left alone, it had lost hardly anything of its power. We regret that the relative consumption of zinc and acid, and the comparative cost of working of the whole battery are not given; but so far as the foregoing data are concerned, the Chutaux evidently promises extremely well. For lecture purposes an electric light is rarely wanted for more than half-an-hour, the great desideratum being a rapid means of charging and discharging the battery. In this respect nothing could be better than the Chutaux; being a single fluid battery, the plates can be raised and lowered easily and rapidly. One of the characteristics of this bichromate battery is the constant percolation of fresh solution through the battery; by this means a good deal of the bad effect of polarisation is got rid of. Here is the composition of the solution for his batteries recommended by M. Chutaux:—

Water	1500 grms.
Bichromate of potash ..	100 ,,
Bisulphate of mercury ..	50 ,,
Sulphuric acid	200 ,,

The electromotive force of such a cell is at first more than twice that of a Daniell cell, but in duration it cannot, of course, be favourably compared.

The cost of working the Chutaux Count du Moncel finds to be about 1·75 francs per cell, which he states is less than that of a Daniell cell, the advantage being that in the Chutaux an electromotive force of nearly double is obtained, and an internal resistance less than half that of the Daniell, besides other obvious advantages noticeable in the working of the two forms. A battery of 24 Chutaux cells, according to our author, can furnish a fairly brilliant electric light at a cost of about 7½d. per hour. If this be the case, the Chutaux battery will rapidly come into use for the purposes of lecture demonstration.

To obtain a transitory current of high potential, nothing seems better adapted than a secondary battery of M. Planté's form. Count du Moncel has fully described these batteries. They consist, as our readers probably know, of either a sheet of lead rolled into a spiral, or successive strips of lead, immersed in dilute sulphuric acid. When the poles of a secondary battery are joined up with two or three Grove cells for a few minutes, finely-divided lead is precipitated on one electrode, and a film of peroxide of lead on the other. Disconnecting the Grove cells, the Planté battery now gives an intense current of its own, which lasts a short time. Here are some effects of the secondary battery. A Planté battery of forty couples joined up with three Bunsen cells for twenty minutes then yielded a current which raised a platinum wire 2 metres long and ⅓ m.m. diam. to incandescence for forty-five seconds, or gave a good electric light for half a minute. Like the residual discharges from a Leyden jar, these batteries can yield successive discharges after a period of rest.

Terrestrial batteries furnish a constant and inexpensive source of electricity. The author describes many forms of earth batteries, which usually depend upon the oxidation of zinc by the humidity of the soil, or the action of the sea water on which they may be floated. A system proposed by M. Lenoir has, however, advantages over the ordinary form. The plates of zinc and coke are placed, each separately, in a large porous vessel filled with moist earth. To one of these vessels is added water containing only a few drops of nitric acid, and to the other (containing the zinc) is added some salt water. M. du Moncel remarks—"In this manner a kind of Bunsen element is obtained, which has considerable power relatively, and far greater constancy, than ordinary terrestrial batteries. This constancy is mainly due, according to M. Lenoir, to the presence of the nitric acid, which weakens the effects of polarisation; M. Lenoir has indeed observed that, without nitric acid, the current produced by this battery soon loses its intensity, but five or six drops of this acid are quite sufficient to give a very marked constancy to the electric current. One very important consequence of employing these currents is that, if used for telegraphic purposes, the insulation of the line wires no longer needs to be so complete as with the ordinary batteries; even when a leakage to earth has been purposely made,—offering but little resistance,—the working of the line has been still quite easy to carry on."

Thermo-electric batteries have as yet been unable to compete with chemical action batteries, but there can be no doubt they will come into extensive use when a pair of metals can be found giving a higher potential and capable of enduring a higher temperature than those hitherto employed. In the work before us, there is a complete *resumé* of the various thermo-batteries. Mure and Clamond's battery seems, so far, the best form. The metals are bars of galena and strips of iron heated by gas or coke, and improved forms of this battery have lately been fully described in this journal. The largest thermo-battery made by Mure and Clamond is one of 150 large couples, equal to about 5 Bunsen cells, and one of 560 small couples, equal to about 60 Daniell cells; each consumed some 800 litres of gas per hour in heating the plates. MM. Mure and Clamond even assert they can construct these batteries equal to 50 Bunsen cells. It would be an invaluable invention if they could be made thoroughly reliable; our kitchen fires, or the backs of parlour grates, might then furnish us with light in our rooms, and the rays of the summer sun might then be transmuted into telegraphic messages. Unfortunately, our experience of these thermo-electric batteries has not been favourable to them, but we live in the age of discovery, and so hope for the revelations of to-morrow.*

Our space forbids us to enter as fully as we could wish into the details of the second volume. Here, as already remarked, is given the amplest information concerning electro-magnetic, magneto-electric, and induction apparatus. Gramme's machine is fully described, and in the appendix its subsequent improvements are added; also the most recent modifications of the various allied machines. In the second chapter, devoted to induction by frictional electric machines, there is the fullest description with which we are acquainted of the numerous species of continuous electrophori, of which the Bertsch, Carré, and Holtz type are best known. We quite agree with the author as to the superiority of the Carré machine. Those who need a thoroughly reliable and powerful electric machine will find in the vulcanite Carré an instrument always ready for use, and not liable to get out of order.

In the fourth section we come to the instruments for, and the methods of, measuring currents. Here we have a perfect galaxy of galvanometers. Galvanometers to suit any current, any object, and any taste. There are few text-books where Weber's instruments are described; here they may be found in full. We

* Since writing the above we have seen a Noé's thermo-battery of 95 elements in action at Mr. Gore's laboratory at Birmingham. This battery is far superior to any that we have tried before; roughly judged, it is equal to about 4 Grove cells, but its elegant arrangements and reliability at any moment make it a most valuable adjunct to a laboratory.

notice a misprint here,—'shunt' is spelt 'schunt.' The word agomètre is new to us; it stands for rheocord, or the double wire arrangement used as as a simple form of rheostat: but the sliding mercury connections are not good,—a metallic clip is better. Coming to electrometers, we find an extremely full and trustworthy account of Sir W. Thomson's quadrant electrometer and replenisher.

The latter portion of this volume is replete with technical information more fitted for the telegraph engineer than the student of science. Here we have the construction and derangements of aërial, subterranean, and submarine lines; the nature of the various faults, and their detection; the disturbances to which telegraph lines are subject; and other practical matters, in which we meet with much that is new and interesting.

In conclusion, we can only repeat in a few words what is evident throughout our notice of this standard work—that it is unquestionably the best treatise we know on the applications of electricity, in the widest signification of the term. It is a work that should be in the cabinet of every physicist, and in the hands of every telegraphic engineer.

Electricity: its Theory, Sources, and Applications. By JOHN T. SPRAGUE, Memb. Soc. Tel. Eng. London: E. and F. N. Spon.

IT is quite refreshing to read a really new book on electricity. Here we have a work which discards the old text-books, bundles over-board the old theories, sets asides old terms, renounces old units and in place thereof introduces new units, re-defines such ancient terms as cannot be sent to the right-about, boldly advances new doctrines, and offers to the reader what with many defects is really a useful and valuable book. The author is evidently a self-worker and a self-thinker, and, like all such "self-help" men, is very dogmatic. "I am Sir Oracle, and when I ope my lips, let no dog bark." Thus "it is stated as a fundamental law that bodies similarly electrified repel each other, *which is not true*, so stated." The italics are the author's, not ours. He has introduced the conceptions of atoms and molecules into matter, and of energy and motion into force, and has shown how electricity is essentially a form of energy and a property of the molecules. He has boldly accepted the doctrine germinated by Faraday and slowly creeping into scientific belief that electricity and magnetism are due to the polarity of molecules, and that we are to search for it not so much in the conductors that bring it within the cognizance of our senses as in the insulating media that are inseparable from its manifestations. It must be confessed, however, that in his explanations of molecular effects he is occasionally hazy; but this is due more to the fogginess of the subject itself than to the style of the author who, when he deals with subjects with which he is practically acquainted, as in electrolysis and electro-metallurgy, is remarkably clear and explicit.

He explains the principles and general phenomena of static or frictional electricity on these views, and gives sound, clear, and very practical directions for the manipulation of instruments designed for the production and manifestation of this branch of the subject. A chapter is devoted to those magnetic phenomena which bear intimately on electricity, and galvanic batteries receive very ample treatment; but he is unjust to M. Leclanché, who has done more real good work towards improving practical working batteries than any one excepting Mr. Fuller (who is not mentioned by Mr. Sprague) since Daniell. Lightning and lightning conductors, electro-magnetism, electric measurements of all kinds, complete a decided addition to our electrical literature.

We, however, come across some very strange paragraphs in a book "written chiefly for that large and increasing class of thinking people who find pleasure in the study of science, and seek to obtain a full and accurate scientific knowledge for its own sake, or as part of the necessary mental preparation for many of the departments of modern life." Speaking of a graduation of a tangent galvanometer,—

"But while I explain this process for the benefit of readers, it is necessary to remark that no one is at liberty to make for sale galvanometers whose dials are thus graduated to indicate the values of the current and resistances in definite units in place of mere degrees of arc, *as this construction is patented.*"

Again:—"I saw also that the plan I had long used personally of measuring currents direct, as described (*but which no one else appears ever to have thought of as applicable to galvanometers*), might be extended so as to make them read off resistances in ohms without the use of the expensive resistance coils. From these ideas has been developed an instrument *which will soon be accessible to the public*, and will, by simplifying the processes of measurement, and placing them fairly in view, tend to spread generally those definite ideas of the measurement of electricity which make it a science instead of a mere hotch-potch of isolated facts, but which are at present confined almost entirely to professional electricians. . . . It shows the current in vebers and in chemics as well as in degrees. It can be made to show any special work, such as the rate of deposition in pounds or in ounces per day or hour of any metal, or to measure other work done. When used with a Daniell cell (or several, as required), the indicator will point to the resistance of the circuit in ohms, and when used with a fixed resistance it will in like manner show at once the electromotive force of any battery used with it. It will thus do for many purposes, without other instruments, and without calculations, the work which at present requires the Wheatstone's Bridge and expensive resistance-coils as well as many calculations."

It is a pity that the book was not delayed in its publication so as to allow its readers to be gratified with a description of this combination of the admirable Crichton and the wonderful calculating boy.

Mr. Sprague is singularly unfortunate in his attack on electrical terms. With respect to quantity he says,—"As it is an evil to change terms once familiar, the term 'quantity' must still be used for this relation of energy to matter; but it cannot be too strongly fixed upon the mind that this word does not mean a *measure*, or the existence of a thing to be measured, but simply a *number* proportionate to the molecular chains in which is set up the condition illustrated in Section 29." (Induction).

Again, with respect to "potential:"—"Words whose meaning is indefinite are delusions, and as electromotive force and tension have definite meanings which the mind can grasp, those words are used here. The idea 'potential' is really meant to convey is one required only in the highest and most delicate branches of electrical science, and the word is best confined purely to its proper object."

The funny thing is that quantity *does* mean a measure, or the existence of a thing to be measured, and nothing else, and it is used in this sense throughout the book; and the word tension is very indefinite, for it is used by Mr. Sprague sometimes to express the constrained position of the molecules of matter under electrica influence, sometimes the amount of electrical energy present, sometimes the difference between the energy of two bodies, and in other senses. Thus he discards a term—*potential*—which has a perfectly definite meaning for one which is ambiguous and misleading, and which all our leading electricians have long since expelled from their vocabularies. However, in spite

of these peculiarities, the book contains a great deal of very useful and valuable matter, and it is one that will not only repay perusal but be useful for reference. The author has favoured us with many original communications, some of which have been embodied in this book; and we hope to continue to be the recipient of his remarks on his own special study.

Electrical Science in English and Foreign Journals.

Comptes Rendus Hebdomadaires des Seances de l'Academie des Sciences. Vol. lxxx., No. 5. February 1, 1875.

On Magnetism.—J. M. Gaugain.—*The Influence of Temperature on Magnetisation.* Mr. Elias mentions * a method of magnetising by heating the bar to redness, suspending it to the pole of an electro-magnet, and allowing it to cool in that position. He continues, "This method is without result." I do not know where the negative results which Mr. Elias mentions are to be found; but before reading his paper I tried to increase magnetism by the use of heat, and in certain instances I think I have succeeded. I first operated under the conditions indicated by Mr. Elias: small bars of steel, 4 to 8 m.m. in diameter were magnetised by putting one of their extremities for some moments in contact with one of the poles of a permanent magnet. I then determined their magnetic condition by ascertaining some points of their curve of demagnetisation; then they were again put in contact with the magnet, this time heating them by an alcohol lamp, and, when cold, were detached from the magnet. The magnetic condition being again determined, I found that the bars were much more strongly magnetised than before. In certain experiments the employment of heat doubled the value of the demagnetising currents. It must be remarked that the increase of magnetism referred to was only produced if the bar, after having been heated, remained in contact with the magnet whilst cooling. If, after the bar had been heated, and while yet warm, a separation took place, the magnetisation instead of being increased was diminished. In the foregoing experiment I occupied myself only with the permanent magnetism first received by the bar *after* separation from the magnet. It was interesting to find out in what manner heat modifies the *total* magnetism developed *during* contact of the bar and magnet. The total magnetisation was found considerably increased by heat; but it sufficed, in order to disperse a part of it, to separate (as before) the bar from the magnet for a few moments. These results appear interesting in so far as they justify the idea generally entertained respecting *coercive force.* This force, considered as a passive force analogous to friction, should retard the movement of the molecules in any direction in which this movement may be directed; and, admitting that coercive force decreases as temperature rises, we may expect that heat should favour magnetisation when the magnetising force gets the better of that coercive force which tends to restore the molecules to their position of equilibrium: on the contrary, heat should encourage demagnetisation when it is the molecular force which prevails over the magnetising force. It appears scarcely doubtful that the three forces just spoken of (magnetic, molecular, and coercive) do not all vary with temperature, but in my experiments the variations of the coercive force have most importance, and they are sufficient to explain the obtained results without requiring to estimate the variations of the other forces.

On Magnetism.—A. Trève.—If the two extremities of a large wire through which a current is passing are placed between the two poles of the large Ruhmkorff electro-magnet, neither spark nor noise is obtained on closing the circuit; but on opening it, a violent report, as loud as a pistol, is heard. Referring to this, Monsieur De la Rive said,—"It seems that the strength of the extra current may be powerfully increased in this case by the influence of the two poles of the magnet." This is the phenomenon now under discussion. Is it necessary to break the current in a position *between* the two poles to obtain this effect? No; if we withdraw from it one or the other of the two poles in order to study the polar action singly, we very soon find that,—1. The phenomenon is reproduced equally in the sphere of attraction of one or the other of these poles; 2. That it is not inherent in the single inducing current, but that the current of the whole battery broken in sphere of attraction, has a like effect; 3. That the extra current increases substantially and even considerably in tension. Oxygen being magnetic, it was desirous to know whether there is not some condensing or separating action on the constituent elements of the air in the magnetic field of the pole. Investigation has not revealed any such actions.

No. 6.

On the Magnetisation of Steels furnished with Armatures.—J. Jamin.—Continuing his paper (Telegraphic Journal, vol. iii., page 59), Monsieur Jamin now gives the results of some studies as to what takes place on re-magnetising the whole magnet with its armatures instead of without its armatures. The direction of his theoretical inquiries are based upon hypotheses enunciated in earlier papers, and cannot be intelligibly abstracted into this column in a small compass. It should be read in the original in conjunction with the previous papers.

Camacho's New Concentric Iron-tube Electro-magnet (See Telegraphic Journal, vol. ii., page 342).—To that notice we add the following abstract: "Experience shows that if we cover up the polar extremities of the tubes which constitute each core of the electro-magnet, by means of an iron shield or plate, the electro-magnet loses its great power and falls back into the conditions of an ordinary magnet. Indeed, the magnetism the shields take will have been developed by the influence of the polar extremities of all the tubes which will touch them; but these polar extremities cannot develop a greater magnetism than what they possess, and that simply upon the atoms of the shields which they touch; hence, the magnetism of the atoms of the exterior sides of the shield will be very weak. Moreover, as the free extremities of the tubes of each core have all the same magnetic pole, the union of them by the shield will produce the well-known weakening reactions attendant on the union of poles of the same name.'

Post-Office Telegraphs.—Statement showing the total number of messages forwarded from Postal Telegraph Stations in the United Kingdom during the week ended the 13th March, 1875, and during the correcponding week of 1874:—1875, 367,005; 1874, 335,400; increase in the week of 1875 on that of 1874, 31,605.—Week ended 20th March, 1875, and corresponding week of 1874:—1875, 389,003; 1874, 343,098; increase in the week of 1875 on that of 1874, 45,905.—Week ended 27th March, 1875, and corresponding week of 1874:—1875, 332,257; 1874, 359,542; decrease in the week of 1875 on that of 1874, 27,285. Easter has fallen earlier this year than in 1874, which accounts for the decrease shown.

To Correspondents.

J. S. J. (Falmouth.)—Declined with thanks. Our correspondent must acquire rhythm and rhyme before we can admit his poetic effusions into our columns.

Mr. David Brooks (Philadelphia).—We regret we cannot print your article except as an advertisement. It is full of errors as regards the practice and the condition of the lines in England.

* "Poggendorff's Annalen," vol. lxii., page 249.

THE TELEGRAPHIC JOURNAL.

VOL. III.—No. 53.

CONTACT *v.* CHEMISM.

THE battle of the guages in the railway world has its parallel in the battle of the theories in the electrical world. Volta conceived the generation of the current in his pile to be due to the contact of dissimilar metals. Fabroni suggested that it was due to chemical affinity. The German physicists—amongst whom we may name Ritter, Pfaff, and Ohm—were ranged on the one side, and the English and French physicists—amongst whom we may name Faraday, Davy, and De la Rive—were ranged on the other side. The first phalanx was supported by the undoubted fact that the contact of two metals, such as zinc and copper, does produce opposite electrical conditions; and the second phalanx was supported by the equally undoubted fact that it was possible to produce currents without the contact of dissimilar metals. Volta determined that in every case the more oxidisable metal was positive, and that the relative order of positive electrification followed exactly the same order as that of oxidability, which led De la Rive to attribute the result to oxidation due to the moisture of the air upon the positive plate; but later observers—especially Sir William Thomson—have shown that this result is independent of moisture, or even of the air, and that it is positively stopped if actual water be present. De la Rive went so far as to say that no effect occurred when one disc was well coated with varnish and a platinum wire is soldered on to it, but Peclet showed that he was wrong. Behrens, in 1805, actually constructed a dry pile of 80 pairs, and De Luc, in 1810, made one of 800 pairs, of tinned iron and gilt paper; and Zamboni, in 1812, made one of 2000 pairs, using paper tinned on one side and pasted with peroxide of manganese on the other. More recently, Sir Wm. Thomson has actually measured the difference of potential between zinc and copper in contact.

Davy, though supporting the chemical theory, found metals to be positive when in contact with dry acids, and negative when in contact with alkalies; and many other observers have noticed that contact difference of potential is not due alone to different metals, but to metals and liquids, metals and gases, and, in fact, to the contact of dissimilar bodies. So that we may say that in the whole range of physical science there is no fact more thoroughly substantiated than that the contact of dissimilar bodies determines a difference of potential between them. Now Faraday and his followers, in supporting the chemical theory, rely on the fact that currents are produced without the contact of dissimilar *metals*; but it is evident that, to destroy the contact theory, we must produce galvanic currents without the contact of dissimilar *bodies*,—and this is simply impossible. On the other hand, it is very easy to produce many instances where currents are produced without chemical action. The ordinary form of Daniell's battery in such general use throughout England is a case in point. There is no chemical affinity between zinc and sulphate of zinc, or between copper and sulphate of copper, and yet arrange these materials in a cell and we have the electromotive force of a perfect Daniell's battery. There is no chemical affinity between zinc and chloride of ammonium, but put them in a Leclanché's cell and we have a powerful current. There are many other insurmountable difficulties in accepting the chemical theory, but the chief objection to it is the answer to the simple question—What is chemical affinity? If we accept the contact theory, we not only accept a feasible theory based on an irrefragable fact, but we answer the question—What is chemical affinity? For, accept the fact that the contact of dissimilar bodies determines a difference of potential between them, we can say at once this is the cause of that action called chemical affinity.

It is said that Volta's theory is opposed to the science of energy. So it was in its original form, but in its modified form—where contact is the prime cause and chemism the effect, sustaining the supply of energy—the difficulty ceases. If we admit that chemical affinity and contact electricity are the same thing, all difficulties cease, and both parties to the contest can retire from the field with the conviction that their battles have been fought, like so many other fierce battles, over a mere difference in words.

AT a meeting of the directors of the Globe Telegraph and Trust Company (Limited) the following interim dividends were declared for the quarter ending the 18th inst. On the preference shares three shillings per share, being at the rate of six per cent per annum, and on the ordinary shares two shillings and sixpence per share, being at the rate of five per cent per annum. The register of transfers will be closed from the 12th to the 17th April, both days inclusive, and the warrants will be payable on the 21st inst.

THE directors of the Western and Brazilian Telegraph Company (Limited) have declared an interim dividend of five shillings per share for the quarter ending the 31st March last, payable on the 15th inst.

THE Great Northern Telegraph Company's traffic receipts for the month of March—this year, 362,145 frs.; last year, 364,579 frs. Total traffic receipts 1st January to 31st March—this year, 884,312 frs.; last year, 982,251 frs.

SPECIAL TELEGRAPHY.

The season of "Special Telegraphy" has set in with a vengeance. During the past fortnight there have been no fewer than twenty-three Race Meetings throughout the United Kingdom, for which special telegraphic arrangements of some kind or other have had to be made; and in connection with these meetings upwards of 20,000 telegrams have been forwarded and received. Northampton, where racing has suddenly revived, and bids fair to regain its ancient prestige, heads the list of important meetings. Here, as many as 4600 telegrams were forwarded and received during the two days of the meeting, being a very large increase on the number for the corresponding event of last year. Warwick, an old established stronghold of racing, comes next, with a total of 4344 messages in three days; and then follow Pontefract, Durham, Windsor, Cheltenham, Croydon, Catterick, Irvine, Packington, Abergavenny, and Croxton Park, with totals varying from 1500 down to 450 messages. The mere mention of these names is sufficient to show the universal character of the sport in England and the all-pervading nature of our telegraphic system. In every one of the cases we have mentioned telegraphic business is carried on at the race-course; and, unlike the system of the late Telegraph Companies, by which an extra charge was levied on all messages forwarded from or received at the Grand Stand, only the "uniform shilling rate" is exacted by the Post-Office for racing as for other messages.

During the present week the racing season will be inaugurated at Newmarket, which, as it is the head quarters of the sport in England, is also the head quarters of racing telegraphy. Last year upwards of 75,000 telegrams were forwarded and received in connection with the seven Race Meetings held at Newmarket, being an average of more than 10,000 messages for each meeting. Of these, more than 12,000 messages, containing 625,000 words, were forwarded on behalf of the press, and more than 1500 were forwarded to the Continent and elsewhere abroad. The principal telegraph office at Newmarket would hardly suffer by comparison with those of some of our largest provincial towns, when it is in full swing during a busy week, such as that in which the "Two Thousand Guineas" or the "Cambridgeshire" is celebrated. On the Heath there are no fewer than three separate offices, each adapted to the varying requirements of the racing public and the press, although never more than two are in use at the same time. Before another year, however, the number of offices will be reduced to two, the Jockey Club having at length determined to erect a series of new stands on the race-course, and having agreed to embrace a "Central" telegraph office in their plans.

Next week several important racing events, involving much special telegraphing, have to be decided. The Epsom Spring Race Meeting, when the "City and Suburban" will be the leading event, takes place on Tuesday and Wednesday; and the New Sandown Park Meeting, near Esher, which aspires to be a kind of Metropolitan Goodwood, occupies the remainder of the week. The Epsom Meetings are old-established affairs, and the telegraphic arrangements in connection with them are a matter of course, just as they are at Newmarket or Doncaster. Nor will there be any lack of accommodation at Sandown Park, although the race-course is barely yet laid out, and the carpenters are still busy with the "Grand Stand." Already the wires have been carried to within a stone's throw of the judge's box; and by this time next week the means will have been provided whereby the result of the "Grand National Hunt" and the "International Steeplechase" may be telegraphed to London and Manchester almost before the winning number has been hoisted on the "telegraph board." The telegraph department of the Post-Office is not above imitating the policy of the old companies in so far as their quest after profit was concerned; but it has taken care to secure popularity as well as profit in its operations, and it has certainly shown wisdom in not handicapping its business in connection with Race Meetings with the objectionable surcharges of the early days of telegraphy.

A NEW DIRECT MEASUREMENT GALVANOMETER.

By J. T. SPRAGUE.

Some remarks in the review (Tel. Journ., p. 83) of my new book—"Electricity, its Theory, Sources, and Applications"—seem to call for an explanation in these pages of the galvanometer of my invention, which the reviewer, somewhat sarcastically, calls a "combination of the admirable Crichton and the wonderful calculating boy."

As to the suggestion that it is a pity that the issue of the book was not delayed so as to allow a description of the instrument, I would remark that the book does contain a sufficient account of it, but that I did not feel it desirable to give such a close description of its actual construction as to enable my readers to make too easily for themselves an instrument on which I have expended many months of work, and gone to the expense of patenting in hope of some repayment for that work. Those who desire a full description will find it in the published specification; for the instrument is not a mere idea, as the reviewer probably supposes, but a completed instrument, which has been subjected to every test. When I speak of it as "*soon to be accessible to the public*," I refer merely to its actual manufacture for sale, which has been deferred because I am not myself engaged in business, and have not (owing partly to illness) as yet arranged for its manufacture and introduction by others. There is therefore no reason why I should have delayed the book, the publication of which has been so long and so often asked for by readers of the papers on which it is based.

The galvanometer is based upon an idea which, when explained, must become obvious to every electrician: it is simply a mechanical application of Ohm's formula—

$$C = \frac{E}{R}.$$

A Daniell's cell is E = 1·079: if we apply it to a tangent galvanometer with a total resistance of 1·079 ohms, we get a deflection which may be 1 or 50 degrees upon any particular galvanometer, according to its nature, but which, whether 1 or 50, is certainly indicative of a current of 1 veber per second. My idea is, therefore, to make this the starting-point of graduation instead of mere degrees of arc, and the result is that, whatever the electro-

motive force or resistance of any other circuit, whenever the conditions are such by Ohm's laws as to give a Veber rate of current, my galvanometer shows it as such, and so for any other current. Therefore any observations made by one person are available for any other, whether their different instruments be constructed for large or for small currents. Now, I have explained in my book how any one can graduate their own instrument on this system if they please, but I cannot conceive what objection there can be taken to my remark that no one must make instruments so graduated *for sale*, because I have patented it. It is possible I may be incorrect in my remark quoted as to this principle of graduation, that no one appears ever to have thought of it as applicable to galvanometers, but certainly I have never seen the idea mooted in any of the many books or papers I have read, nor have I ever seen or heard of any instrument so graduated. I once asked one of our most celebrated instrument makers why galvanometers were not made to show the current in actual units? and he seemed disposed to laugh at me; at all events he told me it was not possible, although my own galvanometers had been so graduated for some time.

Now, with a Daniell cell of constant electromotive force of 1·079 employed, it is obvious that any given current shown by this instrument implies of necessity a given and fixed resistance, and therefore I have only to graduate my instrument so as to show this resistance. Again, if I insert any cell or battery whatever, and make the resistance 1 or 1000 ohms, is it not certain that the current shown in vebers corresponds exactly to the electromotive force producing the current?

The idea once explained, it must be obvious to any one as regards the tangent galvanometer; but I have carried it further. I have found out, by a multitude of experiments, how to construct an ordinary flat coil galvanometer with several circuits so arranged that I can obtain multiplying powers of 1, 10, or 10,000, and thus have made an instrument which can be used to measure such a current as is needed for the electric light, or such as would be given from a single cell through the Atlantic cable, both in vebers, and then, by a slight change, the most delicate traces of electricity.

But any definite current has its fixed equivalent in chemical decomposition, and this the Veber unit disguises. Now I have not, as the reviewer says, renounced old units, and *in place thereof* introduced new ones, but have simply proposed—for all those uses which are related to Chemistry—a simple unit of quantity based upon the chemical relations of electricity, that which affects one equivalent of chemical work of any kind measured in grains, which would, for instance, release 1 grain of hydrogen or 108 of silver. This is the same unit which Smee used, and corresponds to one frequently used by continental writers, viz., a chemical equivalent of 1 decigramme. A unit of current and one of energy complete a system with many points of superiority over the merely mathematical system of the British Association units, as I have fully shown at p. 145 of my book, because it is correlated to the natural constitution of matter, and to its relations to energy, instead of to merely arbitrary human inventions, such as metres and grammes. As a consequence, the graduation of my galvanometer in chemical units converts it into a voltameter, and indicates at once the general chemical work doing, while for special uses it can be graduated to any particular work desired, because any such work has a known and definite relation to my unit of quantity and current.

I shall be happy to show my galvanometer at work, and under any test, either to the reviewer or to any other gentleman who will call upon me in Birmingham, giving a day or two notice in case of my absence from home, and hope soon to be able to make it—as I mention in my book—*accessible to the public*, that being now simply a matter of business arrangement. Once it is so, its convenience and utility will be evident.

HARRISON GRAY DYAR.

Another old electrician has been taken away in the 69th year of his age.

Residing in Europe from 1831 to 1858, and, since that year, in retirement in the United States, Mr. Dyar was comparatively unknown to the present generation, but in 1826-27 he became widely known by his experiments in the then mysterious and unknown paths which afterwards developed the electric telegraph. He anticipated Morse in the introduction of the telegraph into America. In 1828 he erected a line of iron wire on wooden posts with glass insulators, at the old Union Race Course, on Long Island, which he worked successfully with static electricity (the constant battery not having at that time been discovered), the currents transmitted discolouring litmus paper, which was placed in the circuit upon a moving disc or table. We have no record of the length of this line, but the results obtained were deemed so satisfactory that it was determined to build a line from New York to Philadelphia. This project was, however, abandoned, owing to disagreements which arose between his associates and himself. Mr. Dyar had amassed an ample fortune from his scientific pursuits in Europe, which was largely augmented by real estate investments in the City of New York. Personally he was a gentleman of refined and studious tastes. He was born at Boston, Mass., in 1805. He died in Rhinebeck, N.Y., on January 31st, 1875.

Coloured Shadows.—Mr. C. T. L. Whitmell, in *Nature*, writes: Six Grove's cells were connected with one of Ladd's large induction coils, and the secondary current, condensed by two large Leyden jars, was sent, in the usual way, between two pairs of metallic electrodes, in order to examine their spark spectra. Two of the electrodes were of platinum; these may be called pair A. Of the other pair, B, one electrode was of platinum, and the other of the metal to be examined. Place a piece of white paper equidistant from, and on one side of, the two sparks. Hold the finger so that a shadow of it may be cast by each spark. The two shadows will be seen to be most beautifully tinted with different delicate colours, varying according to the metal inserted in B. It will be seen that the shadow thrown by A is lighted by B, and is seen on a ground jointly illuminated by A and B; whilst B's shadow, lighted by A, is seen on the same common coloured ground as before. Without these considerations it might have been supposed that the shadow thrown by B, and lighted by the unchanging spark A, would itself have remained unaltered. I saw it of the colours, pink, light pink, dim pink, light green, nearly white, and yellow-green; corresponding to the introduction into B of Bi, Ag, Sn, In, Al, and Mg respectively.

THE VOLTAIC BATTERY.

A Course of Six Lectures,

By Dr. JOHN HALL GLADSTONE, F.R.S.,
Fullerian Professor of Chemistry, Royal Institution.

Delivered at the Royal Institution of Great Britain.—Christmas, 1874-5.

Lecture IV.—The History of the Battery in its Various Forms.

The history of most human inventions is lost in a mist of obscurity; but it is not so with the voltaic battery. The fact is there are many friends still among us who are older than it. We know all about its origin, and my purpose here to day is to endeavour to trace not merely its birth, but its youth, and how it grew up to its present strong maturity.

Towards the close of the last century there was a physician at Bologna of the name of Luigi Galvani, a man celebrated for original experiments in Anatomy and in Electricity. It so happened that his wife was an invalid, and on one occasion she wished to make some broth of frogs. Now, in preparing frogs for food, you know, they cut off the hind legs of the frog, and some of these hind legs happened to be upon the table, and electrical apparatus was near them. Signora Galvani observed, much to her astonishment, that on bringing a knife near to one of the legs of a frog they were convulsed. She drew her husband's attention to this, and he investigated the matter more fully. He found that it was only when the knife touched the great nerve of the leg connected with the backbone —the crural nerve—that this convulsion took place, and he found also that it only occurred when there was the spark from the machine. But he made other observations beyond that. He thought that if the electrical machine did this, atmospheric electricity ought to do the same. And so he hung up some frogs' legs upon an iron railing near his house, by means of a copper wire passing through or behind the nerve; and then, to his astonishment, he found that it was not necessary to wait for lightning,—for even when the wind blew, and the feet of the frog kicked against the iron railing, the convulsion took place. Now I wish to show you that experiment. I think it is worth while that you should all see it, and see it well. Of course I do not wish you to repeat the experiment, because it kills the frog; but I suppose that not any of us who are in the habit of eating animals in our daily food will scruple to kill an animal for mental food, in this way, and for the purpose of illustrating one of the most important events in the history of Science. Seeing it once, you will not need to commit any cruelty in repeating it. I may tell you, while the frog is being prepared, that the explanation of Galvani was erroneous in the matter. He thought that this frog was something like a Leyden jar. Those of you who have studied frictional electricity will know that instrument. He thought, further, that the frog was a very delicate electroscope, and had the power of charging itself and discharging itself by means of the metals. This was an erroneous opinion of Galvani, and, like most erroneous opinions, it prevented him from getting as much good from his experiment as he might otherwise have done.

In exhibiting the frog we shall throw the oxy-hydrogen light upon it, so that it may be visible to you all, and we shall cast the shadow on the screen, so that those who may not be in a position to see the legs will see the shadow of them. I have here the means of making contact between the copper support and the iron railing through the frog. Upon joining these we shall see the convulsion taking place. See how it kicks in various directions. That is just what Galvani saw, and what surprised him so much. But now we will take a piece of zinc, and see whether we cannot produce the same convulsions; for Galvani tried his experiment in various ways. We will make our frog sit up, if we can, on the zinc. When the copper wire touches the zinc let us see what will happen. The nerves of the poor dead frog have still such activity about them that the legs kick directly the copper and zinc are brought into contact with one another. In 1781 Galvani published these experiments at length in a Latin treatise. They at once drew a great deal of attention to the subject, and they were discussed and criticised by very many. Volta—another Italian, a professor of natural philosophy at Pavia—made experiments upon the subject, and he considered that the explanation of Galvani was unsatisfactory, and that the convulsions had nothing to do with animal electricity. He thought that the secret lay in there having been two metals concerned. You see, there were iron railings and copper wire; and Galvani always found that, to produce the effects well, he had to take two metals and join them together. Now Volta said, very rightly, Why these two metals? There must be something mysterious about the junction of the two; and Fabroni—a professor at Florence—suggested that chemical action might have something to do with the matter. Volta worked at the subject very diligently, and, to prove the importance of the junction of two metals, he produced his celebrated pile. That was the first battery ever formed. We have the pile here. It consists of copper and zinc plates soldered together, and between the pairs there are pieces of flannel or cloth steeped in salt. Acid was sometimes used afterwards, but not, I believe, by Volta. He made a pile of these pieces of metal. We have here fifty-six piled one on top of another, with this salt flannel between them. By taking the two ends—or rather by taking the wires attached to the two ends —we can produce, I dare say, various effects. We can get a spark as you see, and we ought to get a shock very easily by means of this arrangement. I do not know whether we shall be able to make our frog move. [The wires of the voltaic pile were brought into contact with the frog's legs, and produced a sudden convulsion.] Thus you see, at once, the effect produced by means of a pile, which consists of the junction of two metals. Volta, in this way, got Galvani's effects. This pile may be easily imitated by yourselves by putting together almost any pair of metals. You join the two ends, and then you get the effect,—an effect much more powerful when you have a great number of plates. This pile was built up by Volta first in 1799, and he wrote an account of it, and sent it to England to Sir Joseph Banks, the president of the Royal Society, in the beginning of the year 1800. This drew the attention of English experimenters to this subject, and they were soon very fruitful in results.

For instance, there were two men—of the name of Nicholson and Carlisle—who made hastily a pile of zinc plates, copper penny pieces, and pieces of pasteboard damped with a solution of salt; and with this very rough pile they perceived, on bringing the two ends together, that there was an odour about the poles, and this odour they recognised as one which generally accompanied hydrogen gas, and therefore they thought that there was a decomposition of water. This led to other experiments on decompositions, and so they found out, for the first time, that electrolysis of which I spoke in the last lecture. These were, in fact, the first experiments in electrolysis. I must give you the date of them. It was on the 30th of April, 1800, that these experiments were made with the voltaic pile.

We have traced voltaic electricity to England; but let me go back to Italy for a moment. We find that there were two persons concerned in this branch of knowledge,—Dr. Galvani and Volta,—and sometimes the name of one is applied to this force, and sometimes the name of the other. Sometimes we speak of Galvanism, and at other times of Voltaic Electricity. The apparatus is called either the galvanic battery or the voltaic battery, and I did not know at first which term to employ as the title of my lectures; but I chose "The Voltaic Battery" in place of "The Galvanic Battery,"—not that Galvani has not the priority in observation, but that the battery belongs rather to Volta. Galvani never made a battery, and he so misunderstood the force which he had got hold of that he would never have made one. But Volta had a more scientific mind, and he saw that there was something remarkable in the contact of the metals, and that it was not simply an animal phenomenon. And therefore he built up this pile, which is the infant,—the baby,—the very commencement of these various piles which are so powerful, and which we can now exhibit before you.

It so happened that in the same year in which the voltaic pile was known and experimented upon in England—the year 1800, the first year of this century—Davy was appointed Professor of Chemistry in this Institution. He had paid some attention to this matter before he came up from the west of England, and when he came to London he threw his heart and soul into the investigation of this voltaic force. The first course of lectures that he ever delivered in this Institution was upon the voltaic pile and its results. They were lectures delivered in the evening, and they established, to a certain extent, the fame of this young lecturer—Davy. Later on in the year he delivered another course of lectures, which, being in the morning, were attended by the fashionable *élite*, as well as the thoughtful people of the day, and they increased greatly the fame of the philosopher. Davy, in setting to work, appeared to form a sort of determination to tear to pieces everything he could by means of the voltaic power. Of course he was not content with this original structure. In fact, Volta himself improved upon it considerably, and formed an arrangement which I have here, which is called the "Crown of cups." This is an improvement, and is much more convenient than the pile. In fact, the pile is a very inconvenient arrangement. In the improved form you take copper and zinc, and solder them together, connecting them by means of a wire, and then you put them into the cups, or glasses, or jars, in such a way that the piece of copper goes into one jar and the piece of zinc into the next. This is what we call a "couple." The copper of one couple and the zinc of the next couple are in the same jar. You see there is no action between this zinc and copper at all, at present; but if I take the wires at the ends, directly I join the two, you will see that there is an action taking place in all the jars. It is just as if I had joined the plates in each jar. There is now hydrogen being given off in each case. This shows how we can combine many plates together, and in this way we get a much greater intensity of force than we can from any single couple,—more than we could, in fact, from the very large couple which I had in the middle of the room at the first lecture.

Then there was another way of arranging the batteries, which was considered a very great improvement. The plates were soldered together, and put in a trough like this. You had to pour sulphuric acid upon the plates, and then the whole thing was ready for action. There is a wire connected with each end. This is part of the "trough battery" which Davy used. He employed five batteries like that for the decomposition of potassium—the experiment I spoke of in the last lecture. These are called Cruikshank's batteries.

But Davy was not content, even, with his five batteries, which had won for him so many laurels, in the decomposition of the alkalies and alkaline earths. He wanted a larger battery still, and a subscription was set on foot in this Institution, money was collected, and a battery was formed of two thousand double plates. Each plate had 32 square inches of surface, so that altogether there were 128,000 square inches of active surface. What a prodigious amount of power he had here! It is said that it gave a spark, between charcoal points, of 4 inches in length. It was charged with dilute nitric acid. With this very celebrated powerful battery he was able to perform various work in this building, and he thought he could decompose almost everything, but there were some things that resisted even Davy. Of course everything that is simple, and not compound, would resist decomposition; but then he did not know what was simple and what was compound until experiments were made. He, therefore, had a hope of decomposing nitrogen, and he wrote to Mr. Jordan in this way:—"I hope to show you nitrogen a complete wreck, torn to pieces in many ways."

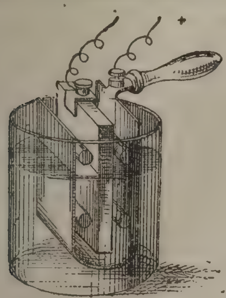
But I must hasten on. Dr. Wollaston, who was well known as a scientific man in those days, made an improvement, by putting the copper on each side of the zinc. Then he could take his cell and put it into dilute sulphuric acid, and, of course, it was acted upon on both sides. You see the great effervescence there is—the great number of bubbles, and this piece of connecting platinum wire has become red hot. Here, then, with a single cell of Dr. Wollaston's, we are able to make a piece of tolerably stout platinum wire incandescent. But Wollaston was not content always with a big thing like this. He had an idea of making very small batteries, and his celebrated battery was in a silver thimble. He took a silver thimble, flattened it considerably, and cut off the end,—that part which is at the end of the finger,—then he put between the two sides a little piece of zinc which was ⅛ of an

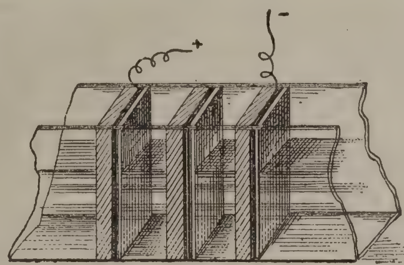
inch square, and then taking some exceedingly fine platinum wire—which he had a special way of making—he was able, by joining the two sides of the flattened thimble to the zinc, to make his little piece of platinum wire red hot. Thus he was able to show this remarkable effect of galvanism by means of his little silver cell. But while Dr. Wollaston was fond of his small battery, there was a Mr. Children who made a very large battery. His plates were 6 feet long and 2 feet 8 inches broad; there were twenty-one cells, and he had to have ropes and pulleys to move these gigantic plates, with which he experimented. But if I were to go minutely into the history of the whole matter it would take me a great many hours instead of one. I will just simply mention that most of those who experimented upon the subject added something to our knowledge of the best forms of battery. Faraday made certain modifications; Mr. Hart made an arrangement by bending the zinc round the other metal in the way that we have it here. Mr. Warren De la Rue was the first, I believe, to employ sulphate of copper. And I will here mention, also, Smee, though he came a little later. Mr. Smee formed this combination, in which he had a zinc plate on each side of a silver plate, but the silver has a little powder of platinum deposited upon it. This is a powerful arrangement, especially useful for electrotyping. Perhaps we may say something more about it when we are speaking of that subject in the next lecture. But the principal advance was made by Prof. Daniell, of King's College. He found that the batteries grew weak, and that they did so from the deposition of hydrogen gas upon the zinc, and thus he was led to devise some means by which to get rid of the hydrogen gas. Here is his battery (see p. 91). I think I will show you first of all this battery, which we can take to pieces. There are two cells, one much smaller than the other, and the smaller one is porous. In the outer cell he placed a copper cylinder, and within that again the porous cell, and inside that cell he put a bar of zinc; then he filled the inner cell with sulphuric acid, and the outer cell containing the copper cylinder with sulphate of copper. On joining the two metals by a wire there is an action through the porous cell, and copper is deposited upon the copper cylinder, and thus no hydrogen is formed at all. It is just as we see it here in the former drawing representing an electrotyping apparatus (see p. 50). Through the kindness of Prof. Adams, of King's College, I have here one of the original cells constructed by Daniell. It is rather more complicated, and very curious in an historical point of view. This is a square, instead of a round, zinc bar, and instead of having a porous cell he first used an ox's gullet. He wanted a stream of sulphuric acid to flow through it, and therefore he had a funnel over the ox-gullet, and a pipe below to carry off the liquid. He joined a good many of these together, round one central reservoir. This, then, is one of Daniell's first attempts in making his well-known battery. Here is a Daniell's cell actually fitted up, such as is used now-a-days. It is just such as I described before, except that—instead of having a glass vessel outside, and the copper cylinder inside it—the copper plate itself forms the outer cell. Daniell's battery was made in 1836; Wollaston's was constructed in 1815.

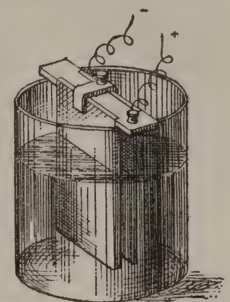
But, very shortly after Daniell introduced this improvement, Mr. Grove—the present Sir William Grove, or Justice Grove—made an advance upon this battery by using other elements. This was done in the year 1839. Here is a Grove's cell. He took a glass vessel, and adopted the plan of bending the zinc which had been suggested before, together with the porous cell of Daniell, and a sheet of platinum. He put the platinum in the porous cell, between the two sides of zinc, and these were made of such a form as to be easily fastened together. As for the liquid element of this battery, the outer cell is filled with sulphuric acid, and the inner one with nitric acid. The nitric acid also prevents the formation of hydrogen; for another gas is formed—a gas which is red in colour, and which, I think, we will produce otherwise. Let us take some nitric acid, and decompose it with a little copper. In this case, you see, we produce intense red fumes. I have taken away part of the oxygen from the nitric acid, and this dense red gas rises up at once. The fumes are very unpleasant, so we will put away the vessel from which they are issuing. This is, in fact, one of the disadvantages of the nitric acid battery. But the advantage is that we get a great amount of power, and we have it very constant, because there is no hydrogen to interfere with the continued action.

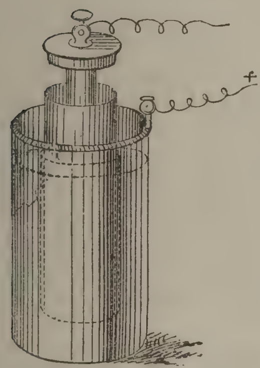
I have below a galvanic battery, in which several Grove's cells are joined together, and I hope to show you one or two experiments which I was obliged to leave out in former lectures. In the first lecture, for instance, I intended showing you how we could produce various convulsive movements of the nerves and muscles. Some of you saw that, because you were good enough to come round the table, and try that little arrangement by which we could give the shocks to human creatures; but not many of you felt those shocks, and I do not think that many witnessed the effect. We have now an eel to experiment upon. We were unable to get an eel last Tuesday, as the weather was too cold, and it was said that the frost had killed all the eels at the fishmongers' round about: but the weather has moderated, and a live eel has been obtained. Here is a Grove's battery. You see there are several cells joined together, so as to carry on the force from one to another; and here is our eel quietly resting at the bottom of this vessel of water; but I dare say that, when we send this force through the water, we can make our eel feel very uncomfortable. [A current from the Grove's cells was passed into the water, and the eel immediately leaped out of the vessel to the floor of the theatre.] The eel had an exciting moment of it, so you must not be surprised at the vigour with which he moves. We made no arrangement for a strong shock: indeed, we ourselves could scarcely have felt the shock that made all this disturbance in the equanimity of the eel.

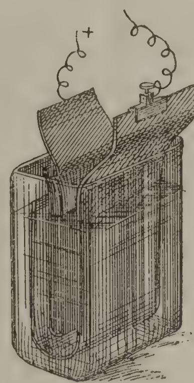
You may remember that, when speaking of electrolysis, I wanted to show you the decomposition of some alkaline salts in solution, but there was no time. I will, however, show you some decompositions by means of this arrangement. Here is a liquid containing chloride of sodium—common salt—and by decomposing that we ought to produce sodium on the one side, and chlorine on the other. Common salt is made of two substances—the metal sodium, and the element chlorine.

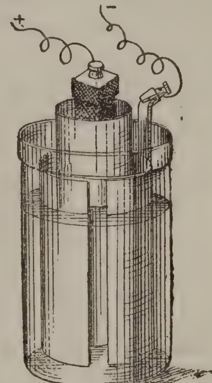

Wollaston's Cell.


Cruickshank's Battery.


Smee's Battery.


Daniell's Cell.


Grove's Cell.


Bunsen's Cell.

I spoke, you may remember, about the various ways in which things were decomposed by the current. I used the word "current" just now. I dare say I have used it before. We are obliged to use words which convey, perhaps, erroneous ideas, and it is very difficult for us to get rid of the tyranny of these words. So I would ask any of you girls and boys to be particularly careful about the words that you use, and to think what is the real meaning of these figures of speech. We cannot help using figures of speech, and I must speak of a current. Well, a current means something that runs like a liquid. In early days they frequently spoke of the "electric fluid," as though something flowed through these wires, and this misled people into the idea that the wire was something like a pipe with water or gas flowing through it. Some of you may think it is difficult to imagine that anything passes along unless there is some material substance going through the wires. I recollect when I was a young scientific man, talking with an old gentleman, who insisted that he could not understand how any effect could be produced unless something flowed along the wire. At last, not being able to convince him, I said, "Do you imagine that when you pull a bell-wire there is a mechanical fluid running through the wire to the bell at the other end?" But he was not prepared to think of a mechanical fluid, and so, perhaps, he gave up his idea of an electrical fluid. Perhaps there is some change taking place in the wire itself—some mechanical or rather molecular change, just as when we pull a bell-wire we know that there is a mechanical change going on all through the wire. So there is, perhaps, some molecular change going on all along the copper wire. What is going on in the case of the solution of salt? There is some change which is producing a great bubbling, whatever else it is doing here; and we shall find, I have no doubt, that, on one side, the chlorine has destroyed the colouring matter that is mixed with the salt; and on the other side we shall find an effervescence due to the sodium. There, I think you will see, at any rate, even now, that there is a difference of colour between these two sides, and that in one case a bleaching has taken place. Here we have iodide of potassium with a little starch. When iodide of potassium is decomposed by the voltaic force, the blue iodide of starch will be formed. Here it is revealing itself by means of its deep blue colour. Here is some sulphate of soda which we will endeavour to decompose in the same way. We might really go on with these experiments *ad infinitum.* When we take such a salt as this, the decomposition will form acid on one side, and alkali on the other, and so we shall have a change of colour in the litmus almost immediately. The white paper behind the glass vessel will help to show it better. While we are speaking of the current going through the liquid, you must understand that there is nothing actually flowing, but there is a force at work. We are obliged to employ these figurative terms and expressions.

I have not referred, as I might have done, to these diagrams. I hope you have been looking to the drawings of the different batteries while I have been speaking of them. The current is represented

as coming from the positive metal, and going to the negative metal through the liquid. We assume that the motion takes place in that direction. And we can always tell which is the direction, if we have a magnet suspended over the wire. I will tell you a way in which you may know it. If we place our arm and hand, palm downwards, along the wire, in the direction of the current, then the north end of the magnet will point in the direction of our thumb, or I may give an explanation such as was given by the great Ampère, who worked out the mathematics of this matter so fully. He supposed that some little fairy or sprite was swimming along with this current; then his left arm would always indicate the direction in which the north of the magnet pointed.

We have two things to consider in these different batteries. One of these is the force which is started by means of the two metals—either the one metal replacing the other, or the two metals which are brought in contact with one another. This is what we call the "electromotive force," and it differs for every two metals that we put together.

Here is a cell of the Maynooth battery, which is essentially the same as the Grove's battery, except that it has a plate of iron instead of platinum, and therefore it is much cheaper. Bunsen, adopting the suggestion of Cooper before him, took coke or charcoal, which of course is also much cheaper. The coke is either derived from the gas works, or is made artificially by roasting a mixture of charcoal and sugar. The ordinary form of Bunsen battery is this: where we have an external cell with a cylinder of zinc, and within it a porous cell with a bar of coke inside. By joining them we get a very powerful battery. The electromotive force between the coke and the zinc is the greatest of all. If we take the power of Daniell's cell as 10, Bunsen's is 16½, and Grove's is 16—very nearly as much—whereas Wollaston's arrangement is only 4. But we have to think, not only of this force which is started, but of another thing, because there is a great deal of work to be done. The force has got to pass along all the wires, and what is much more serious, it has to get through the liquid itself, and the porous cell: and so we have to consider what is called "resistance"—the resistance inside the battery, and the resistance of the wire that is outside, and anything else in its path. Now the resistances have been measured very accurately by those who have experimented on the subject, and I have put here some numbers representing the power of conduction carefully determined by the late Mr. Matthiesen and others:—

Silver	100·000
Copper...	99·950
Gold	77·960
Iron	16·810
Platinum	11·600
Mercury	1·600
Coke	0·025

Silver is the metal that conducts the best, or in other words, offers the least resistance. This force that we are dealing with must pass along by means of something or other. It cannot go along the air, for that is about the most impassable of all bodies to it. But that kind of substance which offers most resistance to us, such as iron bars and bolts, offers free passage to the electric current; so that, instead of its being caged in by metals, it escapes most rapidly by means of them. Silver, as I have said, has the greatest power of conveying the current, and we represent it by 100. Copper has very nearly the same power; gold about three-quarters; iron much less; platinum still less; and mercury least of all those metals. Coke, which is used in Bunsen's battery, has only a comparatively small amount of power to allow the current to go through. You know the common meaning of the word "resistance;" you know, for instance, how much more easily you can go along when you are skating than when you are walking along the ground in the ordinary way. When you are skimming over the surface of the ice, there seems to be no resistance to your progress, except the air, which presses against your body. You flow along with the greatest ease. Now that is something like electricity going through silver. But if you walk through mud or thick snow, there is a large amount of resistance, and you go laboriously; and if you walk through bushes, the opposition to your progress is still greater; and if you come up against a stone wall, a much more serious opposition will be offered to you, and you will be stopped altogether. So it is with this electric force. There are some things which allow it to pass very easily, and other things which stop it altogether; and so between silver, which allows it to pass freely, and sulphur, which stops it altogether, we have a great number of things which allow it to pass more or less readily.

I am sorry the time is passing away so rapidly, because I have other things to show you in the way of batteries; but one cannot say everything in an hour. Here is a chromate of potash battery. It contains chromate of potash and sulphuric acid mixed together, so that it is, more properly speaking, a chromic acid battery. This form is sometimes used for ringing bells. Here we have Leclanché's battery, which is much employed in the Post Office Telegraph Service. We have one of the telegraph batteries in the room. In this battery of Leclanché we have coke with oxide of manganese as the negative, and zinc as the positive metal; while chloride of ammonium is the binary compound in solution.

Beyond these I must mention some other kinds of batteries. Every voltaic cell must consist of three things, I believe; but that they should be two metals and a liquid is by no means necessary. Here is a decomposition taking place with two liquids, sulphuric acid and sulphate of copper, and one metal copper; and here is Grove's gas battery, in which oxygen and hydrogen are used to produce the effect. Here is an air battery which Mr. Tribe and I have been working with, which illustrates the principle, of which the gas battery is an instance. The oxygen of the air acts along with the liquid nitrate of copper that is between the plates; and we are able to produce here another kind of chemical action, which I certainly have not time to explain to you now. Exclude the air which is floating round about us, and this battery will cease to act; but while the air is playing upon the silver, if the junction with the copper is made, the battery is in action.

The last form of battery to which I shall refer is one which, instead of a metal, we have a compound of a metal—chloride of silver. Yesterday, Dr. De La Rue kindly showed me his great battery,

which is made with a thousand cells of zinc and chloride of silver, and solution of chloride of sodium. Here are twenty of these cells. By joining the wires we can get some effect. In fact, with this little voltameter, I shall be able to show you some gas very quickly produced by the decomposition of water. Dr. De La Rue has a thousand of these little cells all in one case; and he showed me, yesterday, some very beautiful effects by means of vacuum tubes, such as I showed you in the first lecture, with those floating bands and striæ of light.

I should have liked to speak to you further upon resistance and such matters, and to show you how you may calculate the power of these batteries, and how, by arranging the cells differently, you may vary the power, and either have a large quantity, or a high tension, so as to overcome a great amount of resistance. The strength of the battery depends originally upon the electromotive force, which is the relation of these metals one with the other; but of course it is diminished by the obstacles to be overcome, and we have simply to divide the electromotive force by the resistance, and then we get the strength of the battery. If any of you who are mathematicians like to enquire further into the matter, I shall be happy to tell you afterwards more about it.

But I want to show you that this power must be very common in nature. I have given you an historical account of the matter, starting with Galvani's experiment on the frog. I have shown you the voltaic pile, and I have traced the battery up from it through the most important forms which it has assumed. There are many other modifications which I have not had time even to mention. But, in fact, we are constantly producing these chemical changes that give rise to voltaic currents, and I want to show you, as the finishing experiment, that most likely, while we were eating our lunch to-day, we were having currents running through us, and were being shocked as the eel was, only to a vastly smaller extent. Here I have an ordinary beefsteak, and an ordinary silver fork. Now if I take a steel knife with this silver fork, I get two different metals. Well, there is an electromotive force when I make the two metals touch; and if I put my fork into the beefsteak, and then cut the steak with the knife, I am sure that there is some chemical change going on between the knife and the fork, because the two are in connection one with the other, at one end through my body, and at the other end by means of a liquid which can be decomposed. I will put my finger on the steel part of the knife, and I hold the metal fork, and thus there will be a current passing through my body. Now I can show that my means of a magnet, if I attach a wire to the knife, and another wire to the fork. Sir William Thomson made an exceedingly delicate instrument for showing the current. This is the instrument. You cannot see the face of it, because we want that for another purpose; but there is a little magnet suspended in the middle of that coil of wire, and upon that is fastened a very light mirror. Upon this mirror the light from the lamp is now being thrown, and it will be reflected by the mirror to the screen. Now, supposing we make the magnet turn, we shall find at once that the mirror will move. We have thus a very long arm of light, which will show if the magnet turns only to a very small extent. This arm of light weighs nothing whatsoever, and so we are able to magnify an exceedingly small movement of an exceedingly small magnet, into something which is visible to all. This "galvanometer" is an instrument which is actually used in the Atlantic Telegraph. You will please watch the mirror. At present our connection is not made, and there is no movement in the spot of light. [The mirror galvanometer just described was attached by means of wires, to the steel knife and silver fork. The fork was inserted into the steak, and immediately upon the knife being brought upon the meat in the act of cutting, the passage of a current was indicated by a movement of the reflected beam of light.]

You see there was a current produced directly I began to cut the meat. We will now reverse the current, and I expect that we shall find that the light will go in the other direction. [The current was reversed with the effect anticipated.]

There, off goes the beam of light towards that little girl at the corner of the front bench.

Notes.

We have to deplore the loss of one of the most amiable and able mechanical electricians of the day. Carl Ludwig Christian Becker was born at Ratzeburg, in the Grand Duchy of Mecklenburg-Strelitz, in 1822. He received his general education at the Gymnasium of Ratzeburg, of which his father was the rector. Having studied his profession with Repsold at Hamburg, Kraft at Vienna, and Steinheil at Munich, he came to London in 1849, and joined the firm of Elliott Brothers in 1858. Within the last few years he became a Fellow of the Royal Astronomical and Physical Societies, and a Member of the Society of Telegraph Engineers. He died April 3rd, 1875, of bronchitis, after an illness of ten days. His place cannot easily be filled, for he combined the refined skill of the brilliant mechanician with the deep insight of the cultivated man of science.

The members of the Staff of the Central Telegraph Station—T.S.—have started a periodical called "The St. Martin's Magazine," which has now reached its fourth number, and which is exceedingly well put together. We wish it every possible success and prosperity. Philology, poetry, ethics, history, fiction, literature, and *on dit*,—all find a place in its well-printed columns. It commenced its existence in manuscript, but its success has been such as to justify the assistance of the printer.

The Dartmouth and Guernsey cable has been again interrupted: the fracture is close to the Guernsey shore, and within the points where it was previously broken. We have not up to the present heard of any steps to effect the necessary repairs.

The Scilly Isles cable has, we believe, a fault in it, but not sufficient to interfere materially with the working. It is supposed to have been caused by a wreck, and the faulty piece will be shortly cut out and the cable restored to its original condition.

The Hon. William Orton, President of the Western Union Telegraph Company, has very recently arrived here from America, on account of business in connection with his Company. It is intended to duplicate the present cable between Punta Rarsa and Key West, and the arrangements for the manufacture and laying this cable forms the principal object of his journey.

The quadruplex question in the United States has recently occupied the attention of Mr. John M. Thacker, the Commissioner of Patents, as regards the question—"The issue before the Commissioner is, to whom shall the patents be granted?" After a lengthy review of the question in its various bearings, he finally decides—"The applications are remanded to the principal examiner, and the patents will issue to Edison and Prescott, as assignees of Edison."

The following is recommended by a correspondent as a cheap battery:—On the bottom of a cylindrical glass jar place a circular disc of iron, having an insulated wire soldered to it. Cover this disc to a depth of about an inch with crystals of copper sulphate. Fill the jar to within an inch of the top with water, and suspend horizontally another disc of iron in the water. Such a battery is said to work household bells for twelve months. We doubt it.

Telegraph clerks will hear with alarm of telegraphic paralysis, a new malady reported by a French physician to the Académie des Sciences. An *employé*, who had been engaged in a telegraph office for nine years, found that he could not form clearly the letters U, represented by two dots and a stroke, I, by two dots, and S, by three dots. On trying to trace the letters his hand became stiff and cramped. He then endeavoured to use his thumb alone, and this succeeded for two years, when his thumb was similarly attacked, and he subsequently tried the first and second fingers, but in two months these were also paralysed. Finally, he had recourse to the wrist, which also shortly became disabled. If he forced himself to use his hand, both hand and arm shook violently, and cerebral excitement ensued. It appears that this disorder is very common among telegraph clerks.—*Graphic.*

We are sorry to record the failure of that well-known and much-respected telegraph engineer, Mr. W. T. Henley. The state of his affairs has not yet been published, and we sincerely trust it will not, but that he will tide over his present difficulties, and have his large works in full operation again.

The annual *conversazione* of the Royal Society, held on the evening of the 7th inst., at Burlington House, was, as usual, brilliant in the gathering of scientific celebrities and apparatus. Prof. Barrett illustrated his discovery of the after-glow in cooling iron wire, and Gore's discovery of the anomalous deportment of iron wire when made red hot by a current. Mr. Culley exhibited Edison's electro-motograph. Mr. Apps showed some beautiful effects with his unrivalled induction-coils. Mr. Ladd showed Dr. Lombard's thermo-electric apparatus. Messrs. Siemens exhibited a model of the *Faraday*, a fragment of basalt and two other stones brought up by a grapnel from 2400 fathoms depth, in the North Atlantic, probably dropped by some passing iceberg. Mr. Warren de la Rue showed some beautiful experiments upon stratification, with 1000 cells of his chloride of silver battery and condensers. There were many other non-electrical displays of great beauty, one of the most attractive being an instrument exhibited by Mr. Crookes, F.R.S., and called the radiometer, which revolves under the influence of radiation; the rapidity of revolution being in proportion to the intensity of the incident rays.

Correspondence.

ELECTRICAL PUZZLES.

To the Editor of the Telegraphic Journal.

SIR,—Before the introduction of systematic testing of lines into India, a vexatious and long interruption to communication was caused by a fault in one or more joints, the interruption only occuring during the night. After sunrise no fault was apparent, and messages were passed freely along the wire.

The wire was No. 1 B.W.G, joints zinc ingots, on the occasion to which I refer. Locality, sea-coast. We arrived at the suspected spot (my suspicion being based on the fact that, within a mile or two on either side, signals had been exchanged on the last night of the interruption; the numerous ingots in a short length, and the appearance of the wire, which was almost double its natural thickness, in consequence of a coating of what looked like common salt). I occupied myself in running out a spare piece of wire, so as to form a loop for about ¾ of a mile; by means of this loop, somewhere like thirteen joints were bridged. As night set in this loop was brought into circuit; and at midnight, on attaching my portable instrument, I was not surprised to find that communication was perfect, and no stoppage whatever had been noticed; on disconnecting the loop an immediate stoppage ensued to through communication.

The piece of wire looped out was next day removed to the nearest telegraph office (the new piece being permanently placed in circuit). On arrival at the stations, signals could barely be passed through two, and not *at all* through a third joint, either during the day or night.

I intend shortly to read a paper on the above, giving all particulars, but in the meantime would be glad to know the opinion of some of the leading electricians who peruse your journal.—I am, &c., MORSE.

March 19, 1875.

P.S.—I might add, to increase the difficulty in solving the cause, that the days were hot and dry during the time communication was perfect. Nights chilly; in with dew, while the interruption continued. As far as I remember, these nocturnal stoppages extended over a period of three weeks.

ENQUIRY.

To the Editor of the Telegraphic Journal.

SIR,—I once read that, if a diamond be laid on a needle, the loadstone would not attract it. Has anyone verified this statement?

INQUIRER.

Electrical Science in English and Foreign Journals.

Comptes Rendus Hebdomadaires des Seances de l'Academie des Sciences. Vol. lxxx., No. 9. March 1, 1875.

Experiments on the Artificial Imitation of Magnetopolar Native Platinum.—M. Daubrée.—It is known that certain samples of native platinum not only act on the magnetised needle, but are even magnetopolar, similar to true magnets. Berzélius, in a paper on the composition of platinum minerals, noted this property in some nuggets from Nischne-Tagilsk (Oural), which he submitted to analysis.* The auriferous sands of Oural, after repeated washings, leave a residuum in which the gold is mixed with a ferruginous substance. To extract this substance a native magnetic oxide of iron magnet was used, and after this would not act, a magnet of native platinum was able to fetch away a still further quantity of iron particles. Such was the experiment undertaken by Kokscharow, in 1866, from which he concluded that natural platinum magnets are much stronger than natural oxide of iron magnets. Sundry analyses have shown that grains of platinum endowed with magnetism are always alloyed with a certain inconsiderable quantity of iron. Under or over a particular quantity the platinum, although magnetic, *i.e.*, capable of being attracted by the action of a magnet, is not itself magnetopolar. Now we know that magnetic mineral substances may, as a result of different operations, become magnetopolar; and Edward Becquerel has shown that platinum, with traces of iron, under the action of energetic poles, may acquire likewise the magnetic property. The examples in which magnetopolar platinum magnets (containing some traces of iron) were successful, is attributed by the author to the influence of the terrestrial globe. To ascertain whether such was the case, some platinum was melted with a small quantity of iron into the form of a bar, the mould, being carefully laid in the plain of the magnetic meridian during the melting and until quite cold. Two very energetic poles were then found at its extremities, placed exactly like those of an ordinary magnetised needle; this was not a chance result. This goes to confirm the importance the globe's general action may have had in the distribution of the different poles of various magnetic minerals and rocks, at the moment when those minerals and rocks were first formed.

On Magnetism.—Count du Moncel.—A series of experiments, somewhat similar to those undertaken by M. Jamin (see abstract of M. Jamin's article on the "Depth and Superposition of Magnetism," in *Comptes Rendus*, No. 7) were carried out by the Count as far back as the year 1862. He had a solid core, and a hollow one, made of exactly equal length and diameter; a solid cylinder was also prepared of such dimensions as to fill up the internal space of the hollow core. The length of the cores was 7 c.m.; diameter 14 m.m.; thickness of the hollow tube 2 m.m. The magnetising coil was wound with No. 16 wire (4-10ths of a m.m. in diameter) 2800 turns, having a length of 228 metres. Twenty of Daniell's elements constituted the battery. At an attractive distance of 1 m.m. the results were:

With hollow core	25 grms.
With solid core	38 ,,
With hollow core, containing the solid cylinder	37 ,,

Having previously observed that extent of polar surfaces played an important part in magnetic attractions, the Count cut off from the end of the solid cylinder a slice 5 m.m. thick, which he fastened to the end of the hollow core by means of a copper pin. The attracting force was also thus increased from 25 grms. to 37 grms., and introduction into the hollow core of the remainder of the solid cylinder (now 6·5 c.m. long) made no difference. Moreover, on taking away the 5 m.m. slice, and leaving the 6·5 c.m. cylinder in its old position, so as to be 5 m.m. distant from the armature, the attractive force fell to 25 grms. This showed beyond doubt that, "in these experiments, as regards the magnetic force developed, *the interior mass of the magnetic core was quite useless excepting in the vicinity of the polar extremity exciting the attraction.*" Continuing the experiments by enveloping the extremity of the hollow core with an iron ring, it was found that, instead of the magnetisation being increased, it fell slightly below 25 grms; and the introduction of the iron 5 m.m. slice failed to restore it to the same power as that of the solid core. From the following formula may be deduced the thickness required by tubular electro-magnetic cores to render them most efficient:

$$c' = c \sqrt[3]{\frac{x^2}{4(x-1)}}$$

here c' = diameter of the hollow core; c that of the solid core, susceptible of being magnetised to saturation under the influence of the current employed, x, the divisor of c', to represent the thickness of the tube which thus becomes a function of the diameter. This value of x may be made as much as 7 without great inconvenience. M. Hughes made it 4 for telegraphic electro-magnets of 1 c.m. diameter.

Annalen der Physik und Chemie, von J. C. Poggendorff. 1875. No. 2.

On the Galvanic Conductivity of Fused Salts.—F. Braun.

Combination of Facts which prove a Decrease of Volume in Consequence of Chemical Transformation in Solid Bodies.—W. Müller.

Electric Conductivity of the Chlorides of the Alkalies and Alkaline Earths, and of Nitric Acid in Aqueous Solutions.—F. Kohlrausch and O. Grotian.

On the Theory of the Galvanometer.—H. Weber.

Reply to Some Remarks, by Baron R. V. Eötvös.—E. Ketteler.

Remarks on Helmholtz's Theory of Vowels.—E. V. Quanten.

A Reply.—R. Schneider.

On the Choice of the Section of Lightning Conductors.—W. A. Nippold.

Remarks on Edlund's Essay on the Nature of Electricity.—G. Baumgartner.

Description of a Very Simple Apparatus for Photographing the Spectrum.—H. W. Vogel.

On the Visible Phenomenon of Interference in Case of Dusty and Unclean Mirrors.—M. Sekulić.

* A magnetopolar nugget is in the possession of the Duke Nicolas, of Leuchtenberg, and weighs 3·833 kilogrammes.

Experiments on Apparent Adhesion.—J. Stefan.

On the Conductivity of the Haloid Compounds of Lead.—E. Wiedemann.

Lymington Literary Institution.—On Tuesday evening, March 16th, a most interesting lecture on "Submarine Telegraphy," was delivered before the members of the Literary institution, by J. Sivewright, Esq., superintendent of postal telegraphs. The chair was taken by the Rev. E. P. Williams-Freeman, M.A., one of the vice-presidents of the institute. The lecture hall was crowded on the occasion, many of the neighbouring gentry being present. The lecture, which was accompanied with many highly interesting and practical illustrations, was listened to with deep attention and interest to its close. The lecturer had last year given a great intellectual treat to the members of the institution, and it scarcely need be said that the high anticipations formed of his second appearance were more than realised. Mr. Sivewright has not only the thorough mastery of his subject, but also the art of making people understand him—being clear, graphic, and not without considerable humour. Mr. Sivewright gave an interesting sketch of telegraphy from its commencement till its application to marine communication, and the laying down of the last Atlantic cable. Specimens of telegraphic cables were exhibited in abundance, and their various defects and excellencies ably pointed out. The progress of submarine telegraphy was ably pourtrayed, and the lecturer showed convincingly that before long the imagination of the poet, "to put a girdle round the earth in forty minutes" will be cast into the shade by the realities of the electric telegraph. As late as 1873 Great Britain was connected with Europe by twelve cables, and with Ireland by five. From Europe to America four cables cross the Atlantic, three from Ireland and one from France, and projects are on foot for the construction of other cables, one to join South America with Lisbon. A cable from Nagasaki to Shanghai now joins the internal system of Japan with the outer world; while, by the submersion of cables from Singapore to Batavia (557 miles), also of another of 1082 miles from Banjoerangie (Java) to Fort Darwin, North Australia, the distant colonies are brought into the telegraph system of the world. The cables laid in the earlier stages of the art have passed through many vicissitudes, and have entailed much loss through imperfect construction, mishaps in laying, failure of insulation, &c. But it is now well understood that, with careful testing and supervision, and with the weight of cable duly proportioned to the strain, &c., a cable forms a permanent property of much value. The maxim is laid down that "there is no decay inherent in the nature of a cable; all deterioration is external."—*Lymington Chronicle.*

Post-Office Telegraphs.—Statement showing the total number of messages forwarded from Postal Telegraph Stations in the United Kingdom during the week ended the 3rd April, 1875, and during the corresponding week of 1874:—1875, 375,821; 1874, 314,773; increase in the week of 1875 on that of 1874, 61,048.—Week ended 10th April, 1875, and corresponding week of 1874:—1875, 400,383; 1874, 342,229; increase in the week of 1875 on that of 1874, 58,154.

The traffic receipts of the Brazilian Submarine Telegraph Company for the three months ending 31st March last, amounted to £34,217.

The report of the Cuba Submarine Telegraph Company just issued states that the revenue account shows a net balance of £6464 17s. 4d., from which, after deducting the debit balance brought from the preceding half-year's account, there remains sufficient to pay the accrued dividend on the Ten per Cent Preference Shares, and leave £1845 0s. 11d. to be carried to the credit of the reserve fund.

Anglo-American Telegraph Company.—The ordinary half-yearly meeting of the proprietors was held on the 9th instant, at the City Terminus Hotel, Viscount Monck in the chair. The noble Chairman, in moving the adoption of the report, said that the efficiency of the work of management had been blended with economy, and he was pleased to say that replies had been received from New York to messages sent from London within the business hours of the day, which, allowing for the difference of time, would only allow one hour for transmission and reply. The average time of sending a message to New York was only ten minutes. The financial position of the company seemed to cause dissatisfaction amongst a number of shareholders. On the 1st of May next, the Anglo-American Company had determined to reduce the tariff to 2s. per word, and he urged upon the meeting not to sanction the publication of accounts or receipts, except at the time of the half-yearly meeting. Captain Hamilton seconded the motion. Mr. John Wilson moved, as an amendment, that the receipts be published monthly. Mr. Dalby seconded the amendment. Several shareholders supported the amendment. When the amendment was put to the meeting it was declared carried on a show of hands. A poll was demanded, the noble chairman announcing that the board held a majority of votes by proxy. The poll was then proceeded with. After a scrutiny of the votes the result of the poll was declared to be:—For the amendment: personal votes, 60; amount of stock, £178,776; number of votes upon that stock, 3955; there were no proxies for the amendment. Against the amendment: personal votes, 25; amount of stock, £58,588; number of votes, 1166; by proxies, 2052 persons; amount of stock, £1,640,000 with 34,018 votes. The majority in favour of the chairman's proposition was therefore declared to be 30,063. The meeting, which lasted nearly five hours, then terminated.

The traffic receipts of the Direct Spanish Telegraph Company (Limited) for the month of March, 1875, were £1475, against £1104 in February.

The receipts of the Submarine Telegraph Company for the month of March amounted to £9289, against £9561 for the corresponding month of last year.

Our Exchange.

All letters must be addressed to the publisher. The column is *free* to subscribers. Non-subscribers pay 6d. for each entry of twelve words, and 1d. for each additional two words. Price in figures counts as one word. Applications, accompanied with stamps and names and addresses, must be sent to the publisher. It is preferred that communication should, as much as possible, be maintained between seller and buyer.

The column is intended to be the vehicle of the expression of wants in books and apparatus, and of a means to supply those wants.

FOLLOWING SURPLUS APPARATUS FOR SALE, In Good Order:—

Electro-magnet, adjustable coils, 10 lbs. of wire, only 42s.—Thermo-electric pile, bismuth and antimony, 25 pairs, well finished, only 40s.—Bichromate batteries, 10s. per cell, cost 15s.—Small voltameter, gold-leaf electroscope, a few vacuum tubes, and other items, can be had for a few shillings each.—Eden, Government Telegraphs, Edinburgh.

To Correspondents.

Mr. Edwards is at perfect liberty to do as he requests, and we wish his venture every success.

THE TELEGRAPHIC JOURNAL.

Vol. III.—No. 54.

DISCOVERIES.

Discoveries in Science are the result either of experiment, of thought, or of chance. An experimental discovery is usually the result of a well-planned attack upon some fortress of Dame Nature —every step, every sap, and every battery, being well considered and faithfully followed; or it results from the attacking force perceiving indications of some sunken mine, or unknown treasure, and following it up with care and determination. Davy's discovery of the safety lamp is an example of the first kind. Something was wanted—its requirements were well defined; Nature was asked to supply those wants and requirements, and she was forced by experiment and enquiry to reply. Faraday's discovery of magneto-electricity was of the second kind. He was engaged in solving a difficult and intricate problem; something attracted his attention, he followed it up, traced it out, and was rewarded with the discovery of what ought to be universally called *Faradaism*.

A discovery the result of pure thought must be based on experience. An experiment sets

—— "that inward eye
That is the bliss of solitude"

a-working. The imagination is brought into play. Thought pictures something that should be, and observation finds out that it is. Graham's discovery of dialysis, and of the occlusion of hydrogen by iron, was of this character. So have been the innumerable additions made to organic chemistry by Liebig and his followers. So have been the strides made in the theory of energy by Mayer, Joule, Thomson, Clausius, and others. Experiment has set the ball rolling, thought has kept it going, and imagination has said "If I only direct it in such a path I am sure to alight on some treasure, or it is sure to bring me to the goal I seek."

Discoveries cannot be said to be the simple result of pure chance. Newton and the apple are said to have led to the discovery of gravitation, but the apple was only the means to direct the thoughts of the philosopher in a certain channel, which certainly led to success, but which had been previously pondering and weighing innumerable other channels and courses. Galvani and the frog are said to have led to the chance discovery of voltaic electricity, but the frog may have jerked its legs on the professor's balcony, or skipped in the physicist's laboratory with the energy of a ballet dancer, before it would have led to the discovery of current electricity unless there had been a trained mind to watch its antics, to follow up its peculiarities, and to ferret out its indications.

Daguerre's discovery of the influence of the vapour of mercury upon sensitive plates of silver is another which is included amongst chance discoveries. He had been experimenting on silver plates rendered sensitive to light by iodine, and had after exposure put them by in a cupboard full of chemicals. To his surprise he found, after a time, pictures develope themselves on the plates, attributing the effect to some chemical. He removed the chemicals one by one, until all had been removed. The effect, however, continued. He then found an unknown and forgotten flask of mercury, which gave out its vapour, and thus produced the effect observed,—and this was the origin of the daguerreotype process. But this was not purely the result of chance. It was the previous training and previous experience which arranged the conditions that led to the discovery, and which enabled the mind to seize upon those very facts which resulted in success. Training and experience are therefore essential in seizing upon abnormal indications of Nature, as they are in comprehending and appreciating her laws and in applying them effectively to practice.

THE ROYAL INSTITUTION.

Notes of a Course of Seven Lectures on Electricity.
By Professor Tyndall, LL.D., F.R.S.
February—March, 1875.

Notes of Lecture IV. *February* 25, 1875.

(Continued from page 78.)

1. In Experiment (9), Lecture III., it is said that if you touch the sphere under induction "anywhere," the repelled electricity will be discharged. This is readily proved by means of the single sphere employed in (9).

2. It is still more strikingly proved by two spheres mounted on insulating stands—say warm tumblers—and connected by a chain. Bring excited glass jar or tube near one of the spheres; the distant sphere is instantly charged with positive, the adjacent sphere with negative, electricity. A carrier which has touched either ball attracts lath. Touching distant ball it repels rubbed glass; touching adjacent ball it repels rubbed gutta-percha.

3. If the distant ball be touched with the finger, its electricity, as might be expected, flows away to the earth. But the same occurs when the *adjacent* ball is touched. In all cases the *repelled* electricity —and it only—is *free*; and no matter what part of the system under induction is touched, the free electricity—and it only—passes to the earth.

4. The induced electricity of both balls may be shown by means of the straw electroscope referred to in Experiment (10), Lecture II. The short arm of the straw being brought within 4 or 5 inches of one of the balls, the straw is positively electrified.

On placing the excited glass tube which has electrified the straw near the other sphere, the index immediately shows repulsion. Touching one of the spheres, or the connecting chain, with the finger, the free electricity—and with it the repulsion—vanishes. On removing the glass tube the liberated negative electricity produces prompt attraction.

5. The prime conductor of the electric machine is charged by induction. When the glass quits the cushion it is positively electrified. A series of points which forms part of the conductor is commonly presented to the glass. From these the negative electricity streams against the excited glass, and neutralises it. The prime conductor thus becomes charged, not by the accession of positive electricity, but by the withdrawal of negative electricity.

6. The charging of the Leyden jar implies induction. The outer coating being connected with the earth, and the inner coating with the electric machine, the electricity poured into the jar acts inductively across the glass upon the outer coating, attracting the opposite electricity and repelling that of the same name to the earth. Two oppositely electrified layers are thus in presence of each other, being separated merely by the glass. On bringing the inner and outer coatings, by means of a discharger, near each other, before contact is established, discharge occurs in the form of a spark.

7. In the first form of the Leyden jar the hand of the operator formed the outer coating, and the water the inner coating.

8. Instead of glass we may employ any other insulator. Dry air may be employed. Two plates of brass—the one insulated, the other not, with a layer of air between them—constitute a virtual Leyden jar. The arrangement, however, has a name of its own—the condenser.

9. In charging the prime conductor of the electric machine, the charge on the conductor continues to augment up to a certain point, after which it is not augmented by the further working of the machine. If the electricity be drawn away from the conductor, and stored up in a Leyden jar, it requires a greater amount of turning to reach the stationary point. This withdrawal of the electricity by the attraction of a layer of opposite electricity is well shown by the condenser.

10. The nearer the two plates of the condenser are to each other the more complete is the withdrawal, and the thinner the glass of a Leyden jar the more complete is the withdrawal. The force of "condensation" in the Leyden jar was proved by Wilson and Cavendish to be nearly in the inverse ratio of the thickness of the glass.

11. The Leyden jar is sometimes perforated by the discharge of the electricity through the glass. A certain thickness of glass is necessary to prevent this.

12. The influence of the oppositely attractive coating may be well shown by laying a sheet of tinfoil on a table, a plate of glass on the sheet of tinfoil, and a second sheet of tinfoil upon the glass. All being loose, let the upper sheet of foil be connected with a gold-leaf electroscope, and with an electrical machine; turn the machine carefully till the leaves show signs of divergence; then lift the glass and upper coating by means of silk loops. Removed from the condensing action of the lower sheet of foil, the electricity of the upper one diffuses itself so strongly over the electroscope that if care be not taken the ruin of the instrument will be the consequence.

13. Sheets of common block-tin, sheets of paper unwarmed, or plates of undried wood, may be employed in the last experiment, instead of the sheets of tinfoil. With the principle of induction for our guide, we can illustrate in various ways the action of the condenser and of the Leyden jar.

14. Canton found that an amalgam of mercury and tin, mixed with a little chalk or whiting, and applied to the rubber or cushion of the electrical machine, greatly augmented the amount of electricity generated. He was led to this discovery by his experiments on the friction of bodies in pure mercury. The amalgam applied to our cushions is formed of 1 part of tin, 2 parts of zinc, and 6 of mercury, rubbed well together in a mortar, and applied to a cushion or rubber on which a little lard has been smeared. The friction of this amalgam against glass always yields positive electricity, whereas the quality of the electricity excited by other rubbers depends—as shown by Canton—in some measure on the condition of the vitreous surface.

15. The action of the *electrophorus*, introduced by Volta in 1775, is also clearly explained by the principle of induction. The flat surface of an insulator is excited by friction. A flat conductor with an insulating handle is brought down upon the excited surface, which acts inductively upon the conductor. Touch the latter, its repelled electricity passes to the earth. Lift the conductor; it is now charged with electricity opposite in kind to that of the insulator. The process of charging and re-charging the cover of the electrophorus may be repeated a great number of times.

The following memoranda connect themselves with those on the distribution of electricity (25 *to* 29, *and* 37 *to* 42) *of our last lecture:*—

16. Monnier proved that the charge of a conductor depended upon its surface, and not upon its solid contents. An anvil weighing 200 lbs. gave a smaller spark than a speaking trumpet weighing 10 lbs. A solid ball of lead gave a spark of the same force as that obtained from a piece of thin lead of the same superficies, bent into the form of a hoop. Finally he obtained a strong spark from a long strip of sheet lead, but a very small one when it was rolled into a lump.

17. Le Roi and d'Arcy showed that a hollow sphere accepted the same charge when empty as when filled with mercury, which augmented its weight sixty-fold. All this proves the influence of *surface* as distinguished from that of *mass*.

18. The distribution of electricity is well illustrated by the deportment of hollow bodies. Impart successive measures of electricity to the interior of an ice-pail, or a pewter pot. On testing the interior of the vessel with a carrier no electricity is found there, but it is found on the external surface. A hat suspended by silk strings answers as well as the ice-pail.

19. The successive charges may be communicated by a metal ball suspended by silk. The charged ball, on touching the interior surface, becomes, as shown by Franklin, completely unelectric. In making the experiment with the hat, note that the electricity is feeble on the round surface of the hat, but dense at its edges and corners.

20. Franklin placed a long chain in a silver tea-pot, with a silk string at one end. Connecting his tea-pot with a pith-ball electroscope, he produced a divergence. Then lifting the chain by the silk he found that over the portion outside the tea-pot the electricity was diffused, this withdrawal of the electricity from the electroscope being announced by the partial collapse of the divergent pith-balls.

21. The greatest experiment of this kind was made by Faraday, who placed himself in a cubical chamber built of laths and covered with paper and wire-gauze. It was suspended by silk ropes. Within this chamber he could not detect the slightest sign of electricity, however delicate his electroscope, and however strongly the sides of the chamber might be electrified.

Experiments in Lecture IV.

(1.) Two insulated balls, 6 feet apart, united by a chain. Rubbed glass jar placed near one of them, that one found charged with negative, and the distant one with positive electricity.

(2.) Touch distant ball, the positive electricity escapes. Touch near ball, the positive fluid equally escapes, flowing, as it were, *through the captive negative electricity* to the earth. Jar removed; negative electricity found afterwards diffused over both balls and chain.

(3.) Distribution of electricity on cone: charge taken by carrier from rounded apex of cone when tested by electroscope obviously stronger than charge taken from rounded base.

(4.) A brass cylinder (wood covered with tinfoil would answer equally well) presents a point at one of its ends *to* the prime conductor of the electrical machine. Working the machine and discharging the prime conductor, the cylinder is found charged with positive electricity.

(5.) Turning the end with the point *from* the prime conductor and working the machine, the cylinder is found charged with negative electricity. In the first of these cases the negative electricity was *drawn* from the point to the positively electrified prime conductor; in the second case the positive electricity was *driven* from the point into the air.

Remark.—The mode of charging the prime conductor described in Note 5, Lecture IV., is illustrated by the first of these experiments.

(6.) Standing on insulating stool, with left hand connected with prime conductor, and sewing needle in right hand, covering the point of the needle with the finger, on presenting hand to the electroscope (4 or 5 feet distant) a very slight action is observed; uncovering the point, the leaves fly violently asunder.

(7.) Mounting a tassel formed of strips of tissue paper on conductor, on turning the machine the strips diverge by mutual repulsion. If the needle with its point covered be presented to the tassel, attraction follows; but the moment the point is uncovered the strips shrink together, and the entire tassel retreats from the point. This illustrates the action of a pointed lightning conductor on an electrified cloud.

(8.) Closing the hand loosely over the needle, long sparks are drawn by the hand from the electrical machine. Causing the point to protrude from the hollow of the hand, no sparks are possible. The broad knuckle or back of the hand, and the finger end, show a similar difference. Presenting the former to the conductor we have dense long sparks; presenting the latter, hardly any sparks at all.

(9.) Take successive measures with a carrier ball (held by a silk string) from prime conductor, or from rubbed glass tube, and put them *into* an insulated ice-pail, a tankard, or a hat. No electricity is found within any of them; but it is found on the external surface of each, from which it may be communicated by a carrier to the electroscope. A mouse within a wire-gauze cage could not be affected by the strongest charge imparted to the cage.

(10.) Franklin's experiment, Note 20, Lecture IV., was made with a small tea-pot and a chain, quadrupled so as to obtain a greater amount of surface. On lifting the chain the gold leaves of the electroscope closed up, on lowering the chain they opened out.

(11.) Cake of resin electrified by fox's brush. Plate of brass with insulating handle placed on the resin. The brass was touched, and the plate lifted. The spark from it ignited a jet of gas.

(12.) A circle of sheet zinc (cut by a pair of common scissors), with a stick of sealing-wax for a handle, makes a very effective electrophorus. Striking a piece of vulcanised india-rubber with fur, and placing the zinc upon it,—on touching the zinc and then lifting it, it is found strongly charged. A half-crown with a sealing-wax handle treated in this way energetically attracts a large balanced lath.

(13.) In all cases the resinous plate, whether it be of ordinary resin, shell-lac, vulcanised india-rubber, or ebonite, proves its electricity to be negative by strongly repelling a rubbed gutta-percha tube. The metal plates, on the contrary, prove their electricity to be positive by forcibly repelling a rubbed glass tube.

(To be continued).

LIGHTNING PROTECTORS.*

By the COUNT DU MONCEL.

Although telegraph lightning protectors are designed for another end than ordinary lightning conductors, they possess a mutual relationship, whereby experiments undertaken for the one are—in a certain measure—applicable to the other. This mutual relation is the preserving action they are called upon to exercise. Now, whether this action is to preserve telegraphic apparatus to which protectors are bound, or buildings upon which they are established, from lightning discharges, it is very certain that arrangements efficacious in one instance will be more or less so in the other. This fact being settled, let us first examine how telegraphic lightning protectors are arranged on a circuit with regard to the protection they are intended to afford.

In a properly constructed telegraph office, the line wire—before arriving at the telegraph instruments—is joined to a "protector," and communication with the receiving instrument is effected through the

* This abridgment was made with the object of furnishing documents to a Commission, appointed by the Préfet de la Seine, to revise the regulations regarding the construction of lightning conductors. Experiments were made at the Administration des Lignes Telegraphiques.

medium of a very fine iron wire, called the *Lightning Arrester*. This may melt under the influence of a tolerably considerable charge of electricity,—thereby putting the line in direct communication with the earth, and isolating the telegraphic apparatus. The connection of the line with the lightning protector is accomplished in front of the "arrester" by means of a branch wire which communicates directly with earth. The lightning protector itself —whose construction is very varied—is so arranged as to present a resistance that may be easily cleared by a strong discharge of static electricity, and yet be sufficiently great to prevent the working current running to earth.

The problem (often studied) respecting the best protecting conditions of telegraph lightning protectors resolves itself into the discovery of such an arrangement as — whilst maintaining a break of continuity in the derivative, and through the "protector" to earth—shall nevertheless permit an easy and quick dispersion of a static electric charge; and it must turn aside such a charge from entering into the receiving instrument, as well as minimise the lateral inductive action experienced on the charge's arrival at the office.

From this simple glance it can be easily understood how, with an electric arrangement just described, the "arrester" may in some fashion serve as a measure of the efficiency of the protector and its branch circuit. It is, indeed, very evident that the greater the protection afforded by the "protector" the less length of wire (composing the arrester) will be melted.

The following are the results of experiments on this question instituted at the "Administration of Telegraph Lines:" they were carried out by help of the large Ruhmkorff coil charged to a maximum with a six-element Bunsen battery, and with a battery of six large Leyden jars:—

1. When the discharge traversed the arrester only (a fine iron wire 1-15th of a millimetre in diameter), it was melted for a length of from 50 to 60 centimetres.

2. When the discharge was bifurcated, one portion through the "arrester" and the other through the "protector," the length of melted wire varied according to the condition of the circuit and the kind of lightning protectors experimented upon.

3. With short circuits, and when no extraneous cause intervened to retard the discharge, the influence due to a particular arrangement of lightning protectors was insignificant, and their protecting power was equal to that of the derivation in which they were placed. They acted then as if this wire preserved its metallic continuity. But such was no longer the case when the circuit presented a certain resistance, or when the discharge was retarded by any means whatever. A retarding effect always takes place during lightning discharges, since the discharge has to pass through a layer of air or clouds more or less thick, and through metallic resistances more or less great.

4. When, by sufficiently retarding the discharge so as to melt the "lightning arrester" for a length of 15 millimetres, and with a communication *direct* to earth through the branch wire, the effect of introducing a protector into the derivation increased the length of the melted portion from 2 to 9 c.m., according to the description of "protector."

5. With "*plate* protectors" (two metallic plates separated by a sheet of mica or gutta-percha) the length of wire melted varied from 20 to 30 m.m.; inversely as the surface of the plates.

6. With a "12-*point* protector the effect was almost the same as in No. 5. But on reducing the number of points to 6, the "arrester" was fused for a length of 4 c.m.; and with all the 12 points blunted, from repeated discharges, fusion took place for a length of 4 to 5 c.m.

7. The preserving action of "*point* lightning protectors" is thus found to be variable in proportion to the number of points and their disposition. Under good conditions their conserving power increases with their number, although generally only one very intense spark is observed at each discharge; but when they are placed in unfavourable conditions their multiplicity is often hurtful, and, with "protectors" of the "point" class, the "arrester" then melted for a length of from 4 to 9 c.m., according to their arrangement.

8. We equally recognise that the number of points necessary to render a "protector" thoroughly efficient must vary according to the degree of their sharpness and size. When they are very sharp and fine their distance apart may be advantageously reduced to a lateral distance of 2 m.m., but if of ordinary size—say that of a stout pin—5 m.m. will be the best distance between them. The separation of the two plates is regulated inversely by analogous conditions; the finer and sharper the points the less necessary for them to approach. The best distance is, nevertheless, 1 m.m.

9. As the action of "protectors" is complex, and since they are intended not only to ward off atmospheric electrical discharges, but also to slowly diminish the tension of storm clouds, it is requisite to examine the question from this latter point of view. We know, from numerous experiments, that *point* "protectors" have, in this latter respect (power of diminishing the influence of storm-clouds), a marked advantage over other systems, although *plate* "protectors" are—as far as can be observed—generally more efficacious with regard to protection. Thus, if the conductor of an electric machine is put to earth through a "protector," the electroscopic effect is noticed to much weaken when a point protector is used, whilst it retains a larger value when a *plate* protector is employed. These facts thus indicate that telegraph lightning protectors should consist both of *plates and points*. The plate system will protect against the lightning-stroke; the point system will weaken the electric influence of storm-clouds.

Having studied the influence of lightning protectors with regard to telegraphic circuits, there yet remains to be examined the influence exercised by earth conductors. Experiments made on this subject led to perfectly unforeseen results. Reasoning upon M. Gaugain's and other physicists' researches, we ought to conclude that static electricity should follow (in its course along metallic conductors) the well-known laws of voltaic currents; consequently it should be admitted that thickness of section of metallic conductors, intended to lead electric discharges to earth, ought to exercise an influence determinable by Ohm's laws. This, indeed, takes place when we experiment with streams of static electricity that have attained their permanent condition; but in the variable period of their transmission their potential is not a maximum, and,

as a lightning-discharge is precisely under this latter condition, it is not astonishing when experiments indicate totally different effects. Now, it has been shown, from some very curious experiments undertaken by M. Guillemin, that the rapid dispersion of an electric charge (after an explosion) depends principally on the *surface* of the conductor leading to earth. *Thus a simple strip of tin exercises a much greater protective action than an iron wire of large diameter*, with a section much more considerable. I had already convinced myself that currents of static electricity in transit through metallic conductors, even copper, encounter a far greater resistance than do voltaic currents; and that they often have greater facility in clearing a break of continuity than in following a metallic circuit, though even a very short one. Thanks to this property, I succeeded in confining—in two different circuits—the inverse and the direct currents of Ruhmkorff's apparatus.

The conclusion of these experiments was, then, that wires connecting lightning protectors with earth should be substituted by metallic strips. The following is the verdict of the Commission for the Improvement of Telegraphic Material on this subject:—"The earth communications of lightning protectors ought to be established by means of copper strips, 4 to 5 centimetres wide, and 1 millimetre (or less) thick. The conductor should communicate with damp soil by means of a metallic plate of at least 1 square metre surface: such a conductor suffices for the wants of a line of 5 or 6 wires."

From the theoretic and experimental studies of Messrs. Kirchoff and Smaasen, respecting the conductivity of indefinite conductors, it results that—if a telegraphic line traversed by a current is put to earth (at its free end) by the medium of a metallic mass, whilst the battery supplying the current communicates with earth in the same manner—*the resistanee of the earth between these two metallic masses is independent of the distance separating them, and varies only with their surface contact.* This VARIATION IS INVERSELY AS THE SQUARE ROOTS OF THESE SURFACES. The deduction to be obtained is that we should establish, as much as possible, electric connection with earth, by means of *the largest possible* metallic plates.

In my recent researches on the conductivity of ligneous bodies I had (on more than one occasion) not only to recognise the truth of this principle, but to verify Kirchoff's conclusions which led up to the law previously formulated.* In addition, here is another experiment, undertaken since the commencement of my researches on Electricity, and which everyone may understand, on account of its simplicity:—Desiring to directly determine, for electric bells, the minimum dimensions suitable for earth-plates when earth formed part of the circuit, I took a Daniell's battery of 8 elements, and, having rolled upon two wooden cylinders (in open spirals) some 3 m.m. diameter galvanised iron wire, I put them in connection with the circuit of the bell. I then immersed, in two different parts of a pond, one of the extremities of each of these two cylinders. Then the cylinders were plunged successively into the water until the electric bells worked. Now I ascertained that to obtain this effect at a distance of 10 metres between the two cylinders, the immersed length of wire should be 34 metres,—*i.e.*, the metallic surface should present at least 32 square decimetres. At a less distance this surface might be reduced, but it sufficed for a greater distance; thus showing that beyond 10 metres the direct conductivity of liquids vanished in the general conductivity of the earth. Later experiments have, moreover, demonstrated that—under ordinary conditions of telegraph lines—the earth's resistance to electric diffusion averages *four thousand metres of telegraph wire.* To overcome resistances of this kind, metallic contact surfaces—larger than those which earth connections of ordinary lightning-conductors possess—are therefore required.

Ordinary earth connections of lightning-conductors are not thus generally regulated. They are often made through kinds of arrows, or iron forks, under the idea that they would facilitate in this manner the dispersion of the conductor's electric charge. It is easy to see that, if such has been the motive, a double error has been committed:—first, because the soil does not behave like an aëriform medium of so small conductivity as air; secondly, because the charge of the conductor of lightning-protectors comes oftenest from the earth.

In Telegraphy preference has always been given, especially in dry ground, to metallic plates; and the want of conductibility in these grounds has been supplied by increased surface of the plates, placing them in the neighbourhood of gutter- and eave-pipes, and taking care to surround them with a sandy or percolating soil. Nevertheless preference is always given, and rightly so, to wells, sheets of water, and water conduits.

As to the conductors communicating with these plates, the metallic strips appointed by the "Commission of Improvements" have been generally supplanted by galvanised iron wire cables, each wire being 3 m.m. diameter. These cables contain as many strands as there are line wires leading to the station, and for certain important offices there may be as many as 150 of them. By this means a great development of metallic surface is obtained, and the construction of these conductors thus becomes easier and less onerous. Perhaps, with this arrangement, there might be reason to fear induction of the wires upon each other,—an effect that might somewhat retard the speed of the electric flow; but, as in a good manufacture (*fabrication*) the strands should touch one another, this action is after all to be little dreaded. It is, however, important that the metallic surfaces should be as clean as possible; hence recourse has been had to galvanised iron.

* These articles appeared in the TELEGRAPHIC JOURNAL, vol. ii.

POST-OFFICE TELEGRAPHS.—Statement showing the total number of messages forwarded from Postal Telegraph Stations in the United Kingdom during the week ended the 17th April, 1875, and during the corresponding week of 1874:—1875, 402,903; 1874, 370,865; increase in the week of 1875 on that of 1874, 32,038.—Week ended 24th April, 1875, and corresponding week of 1874:—1875, 391,403; 1874, 374,056; increase in the week of 1875 on that of 1874, 17,347.

THE Warrants for the dividends on the Ordinary and Preference Shares, declared at the last General Meeting of the Direct Spanish Telegraph Company, Limited,—payable when the balance of the messages accounts to the 31st December, 1874, was received,—were issued on the 27th ult.

NOTES ON MR. EDISON'S ELECTRICAL PROBLEM.

By OLIVER HEAVISIDE.

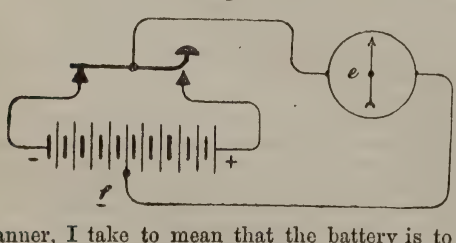
In the Telegraphic Journal for January 15, 1875, Mr. Thos. A. Edison submitted the following problem to its readers for solution :—" Transmit alternately positive and negative currents within a closed circuit from a battery all the poles of which are connected in the ordinary manner, using an ordinary Morse key, to which no extra point or appliances whatever is to be added. No device other than the battery, key, and connecting wires is to be used."

None of the readers of this Journal have as yet come forward with any solution. Why is this? It is certainly not because there is nobody in the British Isles who takes an interest in such matters, and I can only suppose that an excess of modesty has prevented many of the readers of this Journal from sending a solution for publication. As the problem is of a highly interesting nature, I think it should not be allowed to drop out of mind, and so send a few remarks on the problem and its solution. Perhaps others will then come forward with improved methods.

The practical telegraphist who has been accustomed to the use of the Morse key for sending single currents, and a "double-current" key for sending reversed currents, will probably be inclined, on a first perusal, to consider the problem a sort of electrical conundrum, not admitting of any legitimate solution; but such is certainly not the case. I must, however, in the first place, point out that it is an impossibility on the face of it to reverse the current in a *closed circuit* containing a single battery all the poles of which are connected in the ordinary manner: the current in the battery itself has necessarily always the same direction, and a second battery of greater strength would be required to reverse the current in the first. All we can do is to reverse the direction of the current, in some or all of the conductors, in the circuit which lie outside the battery. I assume, therefore, that this is what Mr. Edison means is to be done, and on this assumption we can proceed further with the problem.

The restriction contained in the enunciation that all the poles are to be connected in the ordinary

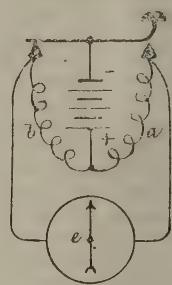
Fig. 1.



manner, I take to mean that the battery is to be joined up "for intensity," to use the convenient old-fashioned phrase; that is to say, the positive pole of one cell is to be connected with the negative pole of the next, and so on all through the battery. This restriction, however, does not forbid us to make a connection by means of a wire between our Morse key and any intermediate pole of the battery, as this will not interfere with all the poles being connected among themselves in the ordinary manner; hence we have the following arrangement, answering every condition of the problem (Fig. 1). The battery *f* has its two terminal poles connected with the back and front stops of the key respectively, and any intermediate pole is connected through the external resistance, *e*, with the lever of the key. This will obviously produce alternately positive and negative currents in the external resistance when the key is worked, and is too simple to require any further explanation. This system was in use many years ago for signalling on underground or submarine wires, and may possibly be still used.

It will be observed that in the above system the whole battery is never in circuit at once; in fact, we are practically employing one battery for the positive currents and another for the negative. If we wish to employ the whole battery both for positive and negative currents we must seek some other plan. Mr. Edison lays no restriction on the *resistance* of the connecting wires, so that, practically speaking, he allows the use of resistance coils. This contradicts the statement in the problem that no device other than the key, battery, and connecting wires is to be used, but we may produce harmony again by uncoiling the wires of the resistance coils. Or, if we have a galvanometer of sufficient delicacy, we may use short pieces of wire. Fig. 2, then, shows

Fig. 2.



a second solution of the problem. The external resistance, *e*, is connected between the back and front stops of the Morse key; one pole of the battery is connected with the lever of the key, and the other with the junction of two wires, *a*, *b*, the other ends of which go to the back and front stops of the key. When the key is in the position shown in Fig. 2 the current from the + pole of the battery divides so that the greater portion goes through *b*, and the remainder through *a* and *e*, to the back stop of the key, and so to the − pole of the battery. When, however, the key is depressed, so that the lever is in contact with the front instead of the back stop, the current from the + pole divides so that the greater part goes through *a*, and the remainder through *b* and *e*, to the front stop of the key, and so to the − pole of the battery. The current is thus reversed in *e*. It is obvious that we can give any relative strengths to the + and − currents in *e* by suitably changing the resistances of *a* and *b*, and that when *a* and *b* are equal the reversed currents in *e* are equal. The galvanometer, *e*, may of course be replaced by a line. The currents sent to line will naturally be less than if the battery were connected direct to line, as in the ordinary double-current key. How much less we must cal

in the aid of Ohm's laws and algebra to determine. Let E be the current in the line, P the electromotive force of the battery, f its resistance, and a and b the resistances of the two wires. Then when the lever of the key rests on its front and back stops, the currents sent to line are—

$$\frac{Pa}{f(a+b+e)+a(b+e)} \text{ and } \frac{Pb}{f(a+b+e)+b(a+e)}$$

respectively; and when $a=b$ each of these becomes—

$$E=\frac{P}{\frac{ef}{a}+a+e+2f} \quad . \quad . \quad . \quad . \quad (1)$$

To have as strong signals as possible with any given line and battery we must make E a maximum subject to the variation of a. Now the denominator of (1) is a minimum when $a=\sqrt{ef}$; therefore E is then a maximum, and its expression is—

$$E=\frac{P}{2\sqrt{ef}+e+2f}.$$

Let us take a numerical case. Let the resistance of the line, including the apparatus at the other end, be $e=5000$ ohms, the battery resistance $f=50$ ohms, then $a=\sqrt{50\times5000}=500$ ohms, and—

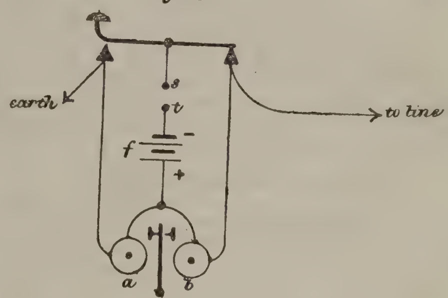
$$E=\frac{P}{2\times500+5000+2\times50}=\frac{P}{6100}.$$

Now, if the battery were joined direct to line, the total resistance in the circuit would be 5050, and the current would be $\frac{P}{5050}$, which is greater than the former result in the proportion of 6100 to 5050; so that the plan of signalling reversals as in Fig. 2 would be attended with a loss of strength of current amounting to about $\frac{1}{6}$ in this particular case. This difference is not very great, but a further disadvantage is that the battery is much harder worked in the system of Fig. 2 than in the ordinary system. These disadvantages would, no doubt, effectually preclude the use of the Morse key for signalling reversals by this particular arrangement; but, on the other hand, it may be adapted to form a system of signalling reversed currents having some advantages over the ordinary method. The principal points of this plan are as follows:—

(1.) The reversals are produced by a Morse key.
(2.) The sending station works his own instrument, so that he may hear or register his signals at pleasure.
(3.) Each station can interrupt the others' sending.

Let the two resistances a and b, in Fig. 2, be the two coils of a Siemens relay, or any other polarised receiving instrument; replace the galvanometer e by the line, and put the front stop of the key to earth. Then we have the arrangement shown in Fig. 3, where the two points s and t may be joined or separated by means of a switch, or any other contrivance. When they are joined and the key is worked reversals are sent to line, just as in Fig. 2 reversals are sent through e. The currents sent split unequally between the two coils a and b, most going through one coil when the key is depressed, and most through the other coil when it is elevated, and the consequence of this unequal alternate division of the current will be that the armature of the instrument will exactly repeat the movements of the key. This is point (2). When it is desired to receive, separate s and t by means of the switch, and the battery will be cut off, and all received currents will pass through both coils in the *usual* manner. Furthermore, as stated above,

Fig. 3.

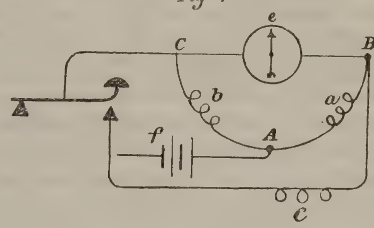


the receiving station can interrupt, for the sender's signals will then be no longer correctly repeated by his own instrument. Possibly Mr. Edison is perfectly well acquainted with this extension, or rather application, of his problem, to the discussion of which we may now return.

If, in the arrangement in Fig. 2, we make the battery and galvanometer change places, we get another—though somewhat similar—method of sending reversals through e. If e is greater than f the currents will be weaker, but if f is greater than e they will be stronger. Otherwise this arrangement is so similar to Fig. 2 as to call for no further comment.

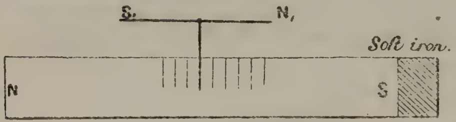
In the previous three methods both stops of the key have been used. In the following only one is used. In Fig. 4, e is the galvanometer or other resistance through which reversals are to be sent; a, b, and c are three resistances; and f the battery. The back stop of the key is not connected with any part of the arrangement. When the key is at rest the current from the + pole divides at A, through the two roads A C B and A B, which join at B, and the circuit is completed through c. When the key is depressed the current divides both at A and at B, and the current in e is reversed. We may also change the positions of the battery and galvanometer in Fig. 4, and still have reversals in the galvanometer. No doubt there are other methods, more or less simple, of obtaining reversals in a conductor by means of a Morse key, and, now that a beginning has been made, they ought to pour in from all parts of the United Kingdom. Mr. Edison's own solutions would also be very acceptable.

Fig 4.



THE NEUTRAL LINE OF MAGNETS.

The following experiment was made to determine whether the position of the neutral line in a magnet was shifted by lengthening it by pieces of soft iron attached to it as armatures :—



N S a steel magnet 12 inches long, 1 inch wide, ¼ inch thick. N_1 S_1 a magnetic needle with a pointer fixed at right angles to it. A piece of paper was pasted to the surface of the magnet, and lines ruled on it 1-10th inch apart.

(1st magnet with no iron to it.)

	Distance from centre.
Neutral point	0·025
⅜ inch iron on end	0·050
¾ " " "	0·10
1½ " " "	0·18
3 " " "	0·25
6 " " "	0·35
12 " " "	0·38
18 " " "	0·40

The iron was of the same section as the magnet. It thus appears that the position of the neutral line does shift.

Notes.

An exceedingly interesting lecture on Science-teaching was given by Dr. Gladstone on Friday evening, April 16th, from which we learnt that the number of classes for Magnetism and Electricity in the United Kingdom, in 1874, was 448, comprising 11,605 students. This subject stands second in popularity among the 23 recognised by the Department, being exceeded only by Physical Geography in the number of those who wish to study it. Its popularity is also growing at a greater rate than that of most other subjects; thus, for instance, while the number of classes in all subjects has not quite doubled during the last four years, those for Magnetism and Electricity have risen from 170 to 448, while six years ago there were only 59 classes. It is also a favourite in the training colleges for elementary schoolmasters. In England it is taught in seven of these colleges to 286 students, and in Scotland—in the two principal colleges—to 170 students. If we add to this the teachers' Science classes at St. Thomas's, Charterhouse, where 103 learnt Electricity and Magnetism in 1874, we have the large number of 559 students who are, or intend becoming, teachers themselves. Besides this, the subject is taken up by a great many pupil teachers, and is taught in some of our best elementary schools; for instance, in the Model School in the Borough Road, and the Practising School at St. John's, Battersea. There were about forty schoolmasters who attended the practical class at South Kensington last summer, and learnt to make such simple and inexpensive but effective apparatus as was exhibited on the table.

A telegram has been received that Mr. F. C. Webb, in the *Ambassador*, has succeeded in laying the Platino-Brazileira cable for Messrs. Siemens Brothers. The last section, from Rio Grande to Chuy, has just been completed, and the *Ambassador* returned to the River Plate for coaling. It is understood she will make an endeavour to recover some of the cable lost with the *Gomez*.

The Indo-European Telegraph Company announce that the average time in transit between London and India *viâ* Teheran, of all outward messages, during the week ending 23rd April, was 1 hour 13 minutes.

The Anglo-American Telegraph Company announce that on and after the 1st of May the rate for messages will be *two* shillings per word.

An announcement is daily expected of the completion of the Direct United States cable. The *Faraday* left on the 5th of April, and is now supposed to be at work on the ground off Newfoundland.

The *Dacia* has been signalled on her outward passage. She has on board about 700 miles of cable for connecting the South American Pacific Coast. She will be shortly followed by another steamer. The *International*, engaged in the same work, has some time since left.

Proceedings of Societies.

THE TELEGRAPH ELECTRICAL SOCIETY, MELBOURNE.

(Concluded from p. 35.)

I might pass over the second question, "What is the use of such a Society?" by simply saying that the objects above stated *prove* the utility of the Society; but a little more may be said on the subject. A good *practical* telegraphist might say, "Why not leave these things to men of science? So long as we can work *their inventions* to *their* satisfaction, and to the satisfaction of our superiors, what need have we to put ourselves out of the way to learn what we can probably very well dispense with?" To that question I would answer, that, if any one has no objection to working like a mere machine, no one has any right to interefere with him. I would be sorry to see any one join this Society against his inclination. A man-machine is a very useful machine, not always as useful as an inaminate one, but possessing some advantages which the latter does not. Now, I do not mean in the least to say, or to imply, that those members of the Telegraph Department who do not join this Society are machines, but I do say, that this Society will be an

excellent means of preventing many of its members from quietly subsiding into that unenviable condition. I, myself, cannot help feeling that there is an actual necessity for me to join a movement of this description in order to prevent myself degenerating, so far as office work goes, into a mere machine; and by devoting a small portion of our spare time to the study we propose, I believe that we will improve our standing as telegraphists very materially. I also think that it is due from us that we should establish a Society of this description in the chief city of Australia, or, I suppose I may say, of the Southern Hemisphere; and should we be successful in the working out of the objects of this Society, a body of efficient practical and theoretical telegraphists will be formed, of the *utility* of which, depend upon it, there will be *no doubt*, and the demand for which will never fail.

This brings me to the last question, "How will the Society be worked?" To that the answer can scarcely be so explicit as to the two first questions. We do not as yet know our strength, either intellectually, numerically, nor financially. But as we may hope to have a sufficient number of members to keep the Society at any rate alive, it will be worth while to devote a few minutes to the consideration of how we may carrry on the work we propose to accomplish. First, as we have already agreed, by the reading of papers contributed by the members, and by discussion thereon. I need scarcely say that it will not be necessary that these papers should be orignal, either wholly or in part, so long as the reader is honest enough to give the name of the author. We may come to that in time, but at present I incline to think that in most cases the less originality there is about the papers, the more solid instruction they are likely to contain. In this paper, with which I am taxing your patience to-night, originality is of course essential, as it treats of no scientific facts, but simply of the establishment of a new and original Society, and therefore I regret I have had very little opportunity for anything like plagiarism. I would suggest that the papers read be more numerous than long. I think that after a few examples of what the papers should be like, but few of the members will find any difficulty in contributing their share. Should, however, the contributions of papers fall short, it will be easy for the Committee to fix upon any subject for discussion, the text-book being some well known work on Electricity. While the papers are being read, those members who wish to profit by them will no doubt take notes. This taking of notes is a most important matter. Mr. W. H. Preece in his lecture makes a special point of it. He says:—"You should always carry with you a note-book, in which everything fresh, everything striking, should be at once jotted down, and there secured as food for reflection. You will thus habituate yourselves to the most invaluable method of fixing upon your minds facts which will be of subsequent use to you. Unless difficulties are recorded when they are met with, or new ideas seized upon and noted down at once, they are apt to escape the memory altogether. I recommend you strongly to write your notes neatly and carefully, and not to destroy them; if they are written on the same sized paper and kept together under their proper subjects, they will prove a never failing source of pleasure." In addition to the reading of papers, it may be at times found advantageous for the members of the Society to meet at the Telegraph Office in order to see practically demonstrated some fact brought before them. I anticipate no difficulty being thrown in our way to such a proceeding, and I may say that I believe this was one reason why the admission of members was restricted to the Post and Telegraph Department. Were strangers admitted, there might possibly be objections raised to their being allowed access to the Telegraph Operating Room.

There is a branch of knowledge which will be found necessary to the student of Electric Science, and which will require special attention on the part of those to whom it is not familiar. I allude to mathematics, and I cannot do better than once more quote Mr. Preece on this point. He says:—

"Mathematics is one of the mind's most valuable assistants. It only needs interpretation; its name frightens. The word mathematics has an alarming sound. Algebra, trigonometry, and the differential calculus are terms that inspire terror into the minds of the uninitiated. But each of these subjects, if energetically grappled with, proves to be so simple that, after once the stile has been crossed, you look back and smile upon the difficulties which apparently encumbered the path, but which existed chiefly in the imagination. . . . No one should be deterred by the letters and symbols which are used to designate mathematical processes, and particularly those who are so used to arbitrary symbols as telegraphists. *Geometry and Algebra are indeed essential* to the skilled telegraphist, and it is difficult for any one to comprehend the higher branches of his profession until he has mastered the elementary principles of these two branches of pure mathematics. It is the application of algebra which enables the telegraph engineer to tell the distance of a fault in a submarine cable to within half a mile, and to direct the sailor, with unerring accuracy, to the spot where he must apply his repairing apparatus. It is trigonometry which enables the sailor by the observation of the sun and stars to direct his ship, though in the middle of the ocean and far away from lands, to this very spot. It is the differential calculus which enables the electrician to obtain the greatest possible speed of working with the least consumption of materials out of his submarine cable."

Another important point to be considered is that of mutual help. Of course there may be always some few who can get on well enough by themselves, but I think that when anyone becomes a member of a Society of this description he is bound to a certain extent to adapt his strength to the average strength of the Society. We are not now preparing to start for a RACE, but for a JOURNEY, and we may have some very rough ground before us. Let us make up our minds to mutually assist each other over any difficulties we may find on the way, and let us make this Society take the place of the *cord* with which Alpine tourists fasten themselves together, and which, though perhaps checking the more rapid advance of some individuals of the party, proves on many occasions the means of a safe journey to the whole of them.

To return to the practical working of the Society, I may say that I think that for the present we will have to confine ourselves to a great extent to the means we have ready to hand, and will have to leave experiments alone until we become stronger in finance. But we have a great deal to learn without even going outside our own office in search of novelties. How few of us, for instance, could set a Wheatstone instrument right if anything went wrong with it, simply because we have never taken the trouble to ascertain the theory of this instrument. There is again the Duplex system of Telegraphy, which I remember thinking, some few years ago, was a wild impossibility, yet which I hope, before long, we will have explained and practically demonstrated to us by one of our members who has devoted a great deal of his time and attention to this problem. Seeing this and other problems practically demonstrated at the Telegraph Office will be one of the advantages of our having restricted the admission of members to the Post and Telegraph Department. In the matter of books, I am happy to say that we have received such assurances of support and encouragement from the heads of the Telegraph Branch, that I believe our slender finances will not be called upon to

provide these necessary auxiliaries, but that the Department will be able to let us have the use, under certain restrictions, of any works which we may consider necessary for the prosecution of our studies. In the same way, I believe that we shall experience no difficulty, perhaps, in having access (of course under restriction) to many useful instruments now in Mr. Ellery's possession or care.

I would also suggest that, as some of the members may be rather backward in even the rudiments of the theory of Telegraphy, we should have, for those who care to attend them, fortnightly meetings (alternating with the Ordinary General Meetings), which might be held in a room of the Telegraph Office, and at which some member, I am sure, could always be found who would be willing to impart to others what knowledge of Telegraphy he may have beyond what the others possess. In this manner we all could be brought up to a more even standard of knowledge of Electricity than exists among us at present, and in a short time the stronger men of science would not find their weaker comrades act as an incubus on them, but they could all go on steadily together.

It only remains for me to point out how country members may assist in working the Society. There are over a hundred country stations. If we can induce (say only sixty) country members to join the Society, I believe we would be able to publish half-yearly a journal containing not only the transactions of the Society, but much other matter (extracted from various works and journals to which we hope to have access), which country members would otherwise never meet with, and which I feel sure will be, to them, fully worth the small subscription they are asked to contribute, even were not the knowledge that by so contributing they are raising the status of the body to which they belong a sufficient inducement to them to join the Society. It is to the country members, then, that we must look, if we are to make this movement anything more than a local one, as it is extremely doubtful if a sufficient fund would be obtained, by the subscriptions of town members alone, to enable the Society to disseminate throughout the whole Department the information they hope to gather by their labours. I feel, however, that I have occupied your time more than sufficiently. I hope that, having once got over the difficulty of starting these meetings, we will spend them more profitably than by reading such papers as I have produced to-night. It was due, however, to the first meeting that something of this sort should be gone through. It is a first push, though perhaps a rather rough one, to the Telegraph Electrical Society, and, thanking you for the patient attention with which you have honoured me, I will conclude by hoping for the Society every possible success.

Some discussion among the members ensued, and a vote of thanks was unanimously given to Mr. L. S. Daniel for his paper.

Notices of Books.

A New Method of Signalling on Railways. Invented and Patented by Sir David Salomons, Bart.

Sir David Salomons, "many years since, struck by the numerous disadvantages which exist in the present mode of signalling on railways," has come to the rescue with a will. His invention consists of laying down a third or centre rail of a smaller gauge than that used for the regular traffic. This rail is divided into sections, according to the requirements of the service, much in the same manner as is now done under the block system. The piece of metal belonging to each section overlaps, and lies parallel to, and on the same level with, but insulated from, that applying to the section in its rear, for a distance sufficient to admit of a train pulling up within the overlapping portions. Under the engine are two metal wheels, borne on one axis, but insulated the one from the other, and both from the engine. These wheels are gauged to run upon the overlapped portion of the signal rail. As this signal rail forms, excepting at the overlapped portion, a continuous line central to the ordinary metals, it is evident one of the wheels affixed to the engine will always be upon it; whilst the other will, at certain points—viz., the points of division of the sections—be upon the overlapped portion of the section in advance.

On the engine is an indicating trembling bell and a battery. One pole of the battery goes to earth by way of the engine. The other pole is connected to that wheel which traverses the continuous line formed by the signal rail. One side of the bell is connected to earth; the other side to that wheel which makes contact with the overlapping portion only of the signal rail. Thus, when a train arrives at the overlapped portion of the signal rail, whilst a train is in the section in advance, the battery current from the engine in advance will flow along the insulated signal rail to that part where it overlaps the section in its rear, and here the wheel in connection with the bell being in contact with it, it will pass through the bell to earth. In passing it rings the bell, and moves an indicator in the direction "train in front." The signal having thus been received, the train in the rear pulls up as quickly as possible, taking care to be within the overlapping portion, otherwise the signal is not received. For the sake of giving early information to following trains, it is also necessary that, in pulling up, it should stand on this portion, which is really the ending of the one and the beginning of another section. By the aid of an additional coil in circuit with the battery, the bell and indicator can be actuated not only by a train in advance, but also by one in the rear; that is, it registers the incoming current from the train in front, and the outgoing current to the train in the rear. There are thus three indications to the one side "train in front;" to the opposite side, "train in rear;" and "bell ringing, but needle vertical, train in rear and in front."

By an application of a modified "Morse" printing instrument, a check is to be kept on the movement of the train; when it stops; when it starts; how long it stops; what signals are received and when, with many others. Sir David even goes so far as to propose a miniature "donkey engine" for the motive power in this arrangement, as it is probable the force of a spring would be exhausted before an engine had fulfilled its whole journey. Further, each guard is to have means of communicating with the driver; the passengers with the guard if requisite. Station agents are to be able to communicate by signal with trains in their sections. Junctions are to be worked by "clerks" placed in offices into which the signal metals are led by wires, so that the entry of a train into the junction section may be ascertained at any moment; that thus certain trains may be stopped whilst others are brought on. In like manner trains are to be started from big stations, by clerks posted in an office for that purpose. The electric current received from a train in advance is to cut off the steam, and thus automatically aid in bringing the train to a standstill. Indeed, it is difficult to see the end of Sir Daniel's invention, so vivid is his imagination, and so enterprising his spirit.

We are afraid Sir David Salomons will find very much more difficulty in bringing his idea into practical working than in designing it. Platelayers are not the sort of men to maintain good an insulated rail, and yet it is evident it must be entrusted to them; for we know how frequently sleepers have to be replaced,

and how uncertain it is when this has to be done. But if, with all the experience of our telegraph engineers, our ordinary telegraphs fail at times through the humidity of our atmosphere, how does Sir David think he will secure the insulation of his rail? True, he says it may be placed at the side of the train, or even overhead, but surely the former would be found but a slight improvement, and very inconvenient; whilst, as regards the latter, we must admit our inability to see how it can be practically carried out. For such a scheme, the "four foot six" is the place, but in what condition the communication would be, and in what state the minds of the officials of the line would be during foggy weather, or during a thaw, can be but too well imagined by those experienced in such matters. Absence of signal is in this system held to be security. We fear it is a *security* which would in the end lead to *danger*.

In part III. of his work, Sir David gives a somewhat lengthy list of *disadvantages* of the present system of signalling, some of which appear to us scarcely well considered. For instance, "the difficulty of distinguishing colours when the eye is tired"—"the non-observance of signals by drunken, careless, or fatigued engine drivers"—"colour blindness of the driver." Sir David should surely know that "colour blindness" is one of the most important points upon which candidates of all classes for railway employ are examined and tested. The difficulty of distinguishing colours when the eye is tired scarcely applies to men in the position of an engine driver; whilst judging from our own experience no class of men, as a rule, are more carefully observant of their duties, or sensible of their onerous character than engine drivers. How it is possible for Sir David's inventions to reduce the dangers of landslips we are at a loss to see; nor can we agree with his conclusion that the system proposed by him would reduce the danger to which men are now exposed when working on the line; increase the dividends of the shareholder, and *decrease* the responsibility of the directors. It is a wild and Utopian idea, and has frequently been proposed before.

Correspondence.

ELECTRICAL PUZZLE.

To the Editor of the Telegraphic Journal.

Sir,—In your Journal of Feb. 15 is published a note from Henry C. Mance, regarding a formula for finding the combined resistance of the derived circuits forming a "bridge," in which it is stated that this problem has been solved without the aid of "Kirchhoff's laws," in a paper communicated to the Royal Society in 1871.

I take the liberty of enclosing a communication from me, published in the *Journal of the Telegraph*, of January 1st, 1875, showing how this result is attained by a process original with me as far as I know. If it differs essentially from that alluded to by Mr. Mance, it may be of interest to your readers as that would be to me.—I am, &c.

A. S. Brown.

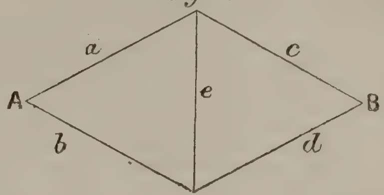
Western Union Telegraph Company,
Superintendent's Office,
New York, March 8, 1875.

From the Journal of the Telegraph, January 1, 1875.

The solutions of the problem of the combined resistance of bridge circuits, furnished by Messrs. Hamilton and d'Infreville, are correct as published in the Journal. The London Telegraphic Journal also published the same solution of this problem. All of these are based on what are known as Kirchhoff's laws. The same result, however, may be attained in another manner quite independent of Kirchhoff's laws.

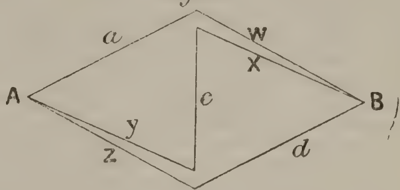
There are three paths for the current from A to B, Fig. 1. 1st, through a and c; 2nd, through b, e, and c; 3rd, through b and d. If these paths can be arranged

Fig. 1.



so that each is independent of and separate from the others (as represented in Fig. 2), the question is reduced to the simple one of finding the combined resistance of three conductors.

Fig. 2.



Imagine the sections b and c (Fig. 1), each split longitudinally into two conductors, and one of each connected, as shown in Fig. 2, to the ends of e. Call the two parts of c, w, and x, and the two parts of b, y, and z. The combined resistance of w and x must equal c, and that of y and z must equal b; from which the two following equations are obtained:

$$\frac{w\,x}{w+x} = c \quad (1)$$

$$\frac{y\,z}{y+z} = b \quad (2)$$

Again, the potential at the point of junction of z and d must be the same as at the junction of y and e. To effect this the resistance y must bear the same proportion to z as $e + x$ to d. This gives:

$$\frac{y}{z} = \frac{e+x}{d} \quad (3)$$

In the same manner the potential at the junctions of a with w and e with x being equal:

$$\frac{a}{y+e} = \frac{w}{x} \quad (4)$$

From these equations the following value of the unknown quantities w, x, y and z is obtained:

$$w = 3818\tfrac{8}{11}$$
$$x = 4200$$
$$y = 2300$$
$$z = 1769\tfrac{8}{13}$$

By substituting these values in Fig. 2 it will be evident that the question is simply to determine the joint resistance of three circuits, *i.e.*:

$$a + w = 6818\tfrac{8}{11}$$
$$y + e + x = 7500$$
$$z + d = 5769\tfrac{8}{13}$$

and the result is $2205\tfrac{14}{17}$.

A. S. Brown.

The Eastern Extension, Australasia, and China Telegraph Company (Limited) have resolved to declare a final dividend of four shillings per share, making with the three interim dividends already paid, six and a half per cent for the year ending 31st December, 1874, free of income tax, carrying forward to reserve £32,839, making a total reserve of £75,453.

Electrical Science in English and Foreign Journals.

Comptes Rendus Hebdomadaires des Seances de l'Academie des Sciences. Vol. lxxx., No. 7. February 22, 1875.

New Researches on the Manner of Intervention of Electro-Capillary Forces in Nutrition Phenomena.—M. Becquerel.—We merely give the title, as the article is medical and not telegraphic.

On the Depth and Superposition of Magnetised Layers in Steel.—J. Jamin.—On December 30, 1872, and later, the author explained certain effects of inverse and direct currents of different intensities upon the same magnet by assuming that the magnetism only penetrates to a limited depth according to the strength of the current, and that the successive actions of the two currents (the first energetic and direct, the second weak and inverse) superpose two contrary magnetisations, the one deep, the other superficial. We only perceive the difference. As this conjecture has been contested, the following experiments, apparently of a decisive character, were undertaken. Into a steel tube, closed by two steel screw stoppers, was introduced a steel cylinder. The whole was magnetised in a coil by a current whose strength was progressively increased. Whilst weak it acted only on the tube, leaving the cylinder free as before; but with a determined force the cylinder became slightly magnetised, the magnetism increasing with the current strength until it attained the same power as that of the tube. To confirm this, the cylinder was first saturated alone with a direct current, and then introduced into the tube; then the whole concern was submitted (in a coil) to an intense and gradually-increasing current. Whilst the current was weak, the cylinder preserved all its magnetism; then, as the current strengthened, the cylinder slowly lost it, afterwards taking another of an inverse nature. There is always a moment in which the whole apparatus possesses no apparent magnetism, and cannot be magnetised by an inverse current, whilst it is energetically magnetised by the direct current which has magnetised the cylinder. But if the cylinder and tube together are thus neutral, it is not in a natural condition; for on separating the two portions, they have different magnetisms,—direct on the cylinder, inverse on the tube; they neutralise one another by super-position. This is what takes place in a single piece of steel when submitted to two contrary magnetisations. More direct methods of proof were instituted, consisting in dissolving the exterior parts of the magnets in diluted sulphuric acid. The results M. Jamin considers to be also conclusive, though the carrying out of the experiments was attended with great difficulties.

No. 8.

Contains no papers on electrical subjects.

No. 10. March 15, 1875.

Electro-Capillary Actions, and the Forces producing them.—M. Becquerel.—A thin platinum plate, full of a large number of small holes, is applied to each face of the permeable partition of an electro-capillary machine. These plates form the electrodes of the couples, inasmuch as they serve for conductors, being in contact with the damp sides of the partition. On the outer face of each of these plates wires of the same metal are fastened, and, including a very sensitive galvanometer, form a closed circuit. The magnetised needle is not deflected, a proof that all the electricity emitted under the reaction of the two liquids is transformed into an electro-capillary current without the intervention of a derived current—an effect contrary to that observed with voltaic currents traversing liquids. The conclusion to be deduced is, that the electro-capillary current, resulting from the reaction of the two solutions upon one another, produces a chemical action equal to that reaction. Numerous experiments prove that the stronger the electromotive force the more marked will be the electro-capillary actions.

On Determining the Quantity of Magnetism of a Magnet.—R. Blondlot.—Referring to M. Rothlauf's discussion in 1861 (*vide Annales de Poggendorff*), on Mr. Van Rees's method of investigating magnetic depth in magnets from its power of generating induced currents, the author declares the theory faulty in two points, and continues—"It may be interesting to examine, from a theoretical point of view, Mr. Van Rees's method; to seek out the exact signification of the numbers which it gives; and in particular to treat of one case where (though it be in general inexact) its application does not entail any appreciable error." The method in question is to insert in a coil, whose wire forms a closed circuit through a galvanometer, a bar magnet, and then sharply to withdraw it to a great distance: the strength of the induced current becomes the measuring quantity. The lesson learnt from the paper (of too mathematical a character for our columns) is that "in a long magnet the magnetism may be considered as accumulated in the neighbourhood of the extremities; consequently, if we place the coil upon the middle part of such a magnet afterwards withdraw it (the middle part) to a great distance, the conditions of the theory are sensibly enacted. Whence it results that the quantity of the current may serve to measure the total magnetism of the half of a bar, provided that it be not too short; that is to say, its distance should not be less than 8 to 10 centimetres. The current is also independent of the diameter of the coil, on condition that its diameter be a small fraction of the length of the bar."

On the Magnetising Function of Tempered Steel.—M. Bouty.—The magnetic moment of a needle may always be considered the product of two factors, one of which expresses the quantity of magnetism in the needle, or, if preferred, the strength of each pole,—whilst the other factor is equal to the distance of the two poles. The determination separately of these two distinct elements, and the study of the variation of each of them under changed magnetising conditions, occupied M. Bouty some time, and his investigations are still incomplete.

No. 11. March 22, 1875.

A New Electro-Medical Galvanoscope.—J. Morin.—Consists of an ordinary two-branch electro-magnet, placed vertically, the breach being in the air. A magnetic needle is suspended by one of its poles over the breach, through which it penetrates by means of a large hole. The lower free pole of the needle descends as far as the level of the lower part of the electro-magnet's helices, between which it is able to oscillate. The needle is long enough to penetrate the breach to the height of its neutral point, thus nullifying at that spot all reciprocal action. On making a current circulate in the helices the two poles act in the same direction upon the free pole of the magnetic needle, causing it to be displaced towards one of the helices according to the direction of the current. This apparatus is said to answer the purpose for which it has been devised.

On Magnetisation.—J. M. Gaugain.—A continuation of some former articles.

No. 12. March 29, 1875.

Contains no papers of interest to our electrical readers.

Bulletino Telegrafico. Anno xi. January, 1875.

This issue is entirely taken up with personal and other official matter.

THE TELEGRAPHIC JOURNAL.
Vol. III.—No. 55.

LIGHTNING.

There are indications that we may anticipate severe electrical disturbances during the coming summer. The winter has been unusually long and severe. Abnormal weather has occurred over most parts of the globe. Reports of severe thunderstorms reach us from the Cape and the antipodes. Exceptional conditions of this kind abroad usually presage similar conditions in England. "Coming events cast their shadows before." But whether the coming summer be above or below the average in lightning accidents, we are none the less bound to call attention to the fearful apathy and gross carelessness evinced in protecting buildings from atmospheric electrical discharges.

During two severe storms in England, in June, 1872, there were ten deaths and fifteen cases of injury to human beings; sixty houses struck, and fifteen burnt down; and twenty-three horses or cattle, and ninety-nine sheep, killed. Those accidents that are not recorded are innumerable. In large towns damage to property is more frequent than destruction of human life, but in the open country destruction of life is perhaps more frequent than destruction of property, unless we except trees, which are ruined in thousands every year, and unfortunately—from their size and growth—the finest suffer.

Lightning protection is therefore not only a necessity, but it is a source of satisfaction and comfort. It is difficult to comprehend the reasons why it is not more largely adopted. It is not its inutility—for the beneficial effect of lightning-conductors amongst our buildings and our shipping is incontestible. It is not its expense—for a house can be protected for a less sum of money than is required to bed out a parterre. It is not its difficulty—for any skilled workman or energetic landlord can do it with ease.

Dr. Mann, the President of the Meteorological Society, has done good service in reading an exhaustive and able paper on the subject before the Society of Arts, and an admirable notice was given of it in the *Times*. Dr. Mann has supplemented this notice with an excellent letter to the leading journal on the precautions to be taken, especially with the tall zinc tubes now so largely used for chimney-tops. Mr. Preece had previously called attention, in the *Times*, to the danger of chimneys, lined as they are with soot, filled with ascending currents of heated air and smoke, and terminated in grates, acting as lightning-conductors. If all such chimney-pots be connected with the water-pipes by galvanised iron ropes, and if all these pipes make good earth, a house is as safe from lightning as a collier in a mine.

All lightning-protectors should be constructed on proper scientific principles, and we have published in our columns many valuable papers on the subject. The great desiderata to be urged are—the employment of perfectly continuous metallic ropes or rods, the use of good earths, and the termination of the conductors in the air in points. A great fact to be remembered is, that joints, and earths, and points deteriorate, and lose their efficiency: they therefore require frequent examination and frequent renewal. Lightning-conductors require annual inspection and careful overhauling.

It is needless to point out to telegraphists the necessity of a good earth, for they all know that their circuits are unworkable without them; but it is lamentable to see the condition of the earths to the lightning-protectors of the steeples of some of our cathedrals and churches. The splendid new spire of Llandaff cathedral is positively in a dangerous condition from this cause. Nine out of every ten churches are in the same condition. Earth-wires are plunged into the interior of cisterns; they are leaded into stones; they are bedded in dry sand. One was carefully put into a glass bottle buried in the dry earth; another was coiled carefully into the interior of a wooden pail, in the basement floor of the house it was meant to protect. Every case of the inefficiency of lightning-protectors that has been examined has been proved to be due to the existence of such gross ignorance of the commonest principles of electrical science as is evidenced by the above cases.

The country is now overrun with telegraphs. Telegraphists are to be found everywhere. There is no difficulty in securing the advice and assistance of skilled men, and our churchwardens and church dignitaries would do well to call such experience to their aid. It is better to lock the stable door before the steed is stolen.

Post-Office Telegraphs.—Statement showing the total number of messages forwarded from Postal Telegraph Stations in the United Kingdom during the week ended the 1st May, 1875, and during the corresponding week of 1874:—1875, 394,518; 1874, 377,849; increase in the week of 1875 on that of 1874, 16,669.—Week ended 8th May, 1875, and corresponding week of 1874:—1875, 402,502; 1874, 375,870; increase in the week of 1875 on that of 1874, 26,632.

The Manager of the Direct Spanish Telegraph Company, Limited, informs us that the average time occupied in the transmission of telegrams between Madrid and England, *via* Santander, during April, was 2 hours and 57 minutes (including transmission over Spanish land-lines).

CENTRAL TELEGRAPH STATIONS.

The great commercial capitals of the world, London and New York, have, within a very short period, been provided with Central Telegraph Offices which for extent and completeness are unequalled elsewhere. The Central Telegraph Station in St. Martin's-le-Grand, and the new offices of the Western Union Telegraph Company in Broadway, New York, may be regarded as evidences of an amount of progress such as has attended few institutions in our time. Less than thirty years ago the "system" of the late Electric Telegraph Company—or, to speak more correctly, the telegraphic system of the United Kingdom—consisted of a line to Nine Elms, and a small office at 334, Strand. Similarly, in 1846, a single wire was erected to an obscure office beneath the express offices at No. 16, Wall Street, New York, and two wires from Washington terminated in a small room over the Ferry-house in Jersey city, where three clerks easily—and not very continuously—performed the whole telegraphic business of the city of New York. We need not trace the progress of the Electric Telegraph Company eastwards until it acquired extensive offices,—first, in Founders' Court, Lothbury, and subsequently in Telegraph Street, Moorgate Street. Nor need we do more than simply mention the British and Irish Magnetic Telegraph Company, with its offices in Threadneedle Street, and the United Kingdom Telegraph Company, located in Gresham House. All three were eventually housed in the premises built by the Electric Company in Telegraph Street, and thence the next move was to the new Post-Office in St. Martin's-le-Grand. This event occurred on the 17th of January, 1874; and little more than a year afterwards—viz., on the 1st of February last—the Great American Telegraph Company moved to its new premises in Broadway, New York.

The American structure has been erected at a cost of more than two million dollars, and a considerable portion of this amount has been subscribed in England—chiefly in London, we believe. It is built of brick and granite, in what, with some latitude, may be designated as the French Renaissance style, the main idea in its construction being to reduce in appearance—by the proportions and the arrangement of the details—the great height of the building, as compared with its width or front. The building is said to be fire-proof throughout, wood having only been used for the doors, window-sashes, and the wainscoting. Most people are familiar with the appearance of our new Post-Office buildings in St. Martin's-le-Grand. Many regard them as being wholly devoted to telegraph purposes; but it should be explained that only the top floor, the basement, and one or two rooms on the intervening floors are so occupied. The building of the Western Union Telegraph Company, in New York, extends to the height of no fewer than ten separate floors, and is mainly occupied by the various offices of the Company; but it is with the operating rooms, situated on the seventh floor, just as it is with the instrument galleries in St. Martin's-le-Grand, that we are mainly concerned in speaking of both as central telegraph stations. The American room is 145 ft. long, 70 ft. wide, and 23 ft. high, or about the size of the central gallery in St. Martin's-le-Grand. This gallery, supplemented by the side wings, and forming a space somewhat resembling the letter H, has a superficial area of not less than 20,000 feet; so that the American room is not much more than half the size of our own. The instrument tables do not extend to more than 500 ft. in length in New York, while those at St. Martin's-le-Grand extend to 2800 ft., or more than ½ a mile. In America, where the system of "sound" telegraphy prevails to a large extent, the tables are cut into short lengths, each separated into four compartments, so as to isolate the operators from each other and to confine the sound as much as possible. Here, owing to the variety of systems employed and the extensive use of automatic instruments, the tables are of considerable length, and are open throughout. In the Western Union Company's new office less than 200 instruments of all kinds are employed, including 149 Morse instruments, 15 sets of duplex apparatus, and 6 of Phelps's printing instruments. In St. Martin's-le-Grand the total number of instruments exceeds 450, and includes 195 Morse printers, 122 single needle instruments, 65 sets of duplex apparatus, 53 sets of Wheatstone's automatic instruments, and 18 of other sorts. The switch or test board of the American office is arranged for the distribution of 300 wires; that in our own Post-Office building is arranged to accommodate 800 circuits, and if need be the provision can be extended to 1000 lines without difficulty. Batteries, which are to the telegraph what the boiler is to the locomotive, are always an object of anxiety in planning a large telegraph office. They cannot well be situated in the instrument room on account of their peculiar construction and their continual wants, and yet they should not be too far away from it. In this respect the New York Office, where the batteries are stored in a room immediately underneath the operating room, has a decided advantage over the London Office, where several floors intervene between the instrument galleries and the battery room. In extent, however, the two departments are as widely different as are the arrangements in the respective instrument rooms. In the Western Union Company's Office provision is only made for a *maximum* power of less than 17,000 cells, while the number of cells actually in use does not exceed 7000. At St. Martin's-le-Grand 50,000 cells can readily be accommodated in the large room in the basement of the building set apart as a battery store, while at the present moment not fewer than 23,000 cells are actually in use. Not far short of 2 miles of shelving have been constructed in this room for the reception of batteries, and a perfect avalanche of wires descends from the instrument galleries above, in order to transmit the motive power to the 450 instruments, whose wants are as numerous as they are varied and unceasing. Including these cattery connections, and other connections between different points in the instrument galleries, not less than 260 miles of gutta-percha covered wire are buried under the floors of the building in St. Martin's-le-Grand.

We have been struck with the small extent of the pneumatic system in the great Telegraph-office of New York. Apparently the system is confined to the building itself, and does not extend beyond the receiving and delivery departments. A single 20-horse power engine is all the motive power required in connection with this department, the remaining machinery—situated in the basement of

the building—being required in connection with the elevators, and for heating purposes. The pneumatic system at St. Martin's-le-Grand is one of the great features of the building. No fewer than twenty-five separate tubes communicate with out-stations in the Metropolitan district, ranging from Fenchurch Street and Tower Hill in the east, to Temple Bar and Charing Cross in the west. These tubes extend to a length of nearly 18 miles, and are worked outwards by pressure and inwards by vacuum. In addition to these outlying tubes there are twelve tubes within the building itself, used for blowing messages between one part of the instrument galleries and another. So rapidly is this effected that an average of four seconds only is occupied by the "carrier" in making the journey across the room, or from one wing to another, as the case may be. The motive power by which the tubes are worked exists in the basement of the building, in the shape of three steam-engines, each of 50-horse power. Two of these are constantly employed in pumping air into, or sucking it out of, huge mains carried up the outer walls of the building, and connected with the tubes upstairs. The third is at rest, ready for any emergency, or to take the place of that whose turn for rest next comes round. The engine-room resembles nothing so much as the hold of a great steam-ship, and, from the peculiarly interesting character of the machinery, it is a great source of attraction to the numerous visitors to the Central Telegraph Office. Four boilers, each of 50-horse power, and fitted with Vigars's patent stokers, occupy a corresponding position of the basement to that occupied by the engines; and an Artesian well is in process of sinking, which, it is hoped, will supply not only the boilers, but the whole of the building, with water.

It only remains to notice the *personnel* of the two great telegraph offices of the world, and to sum up the amount of business transacted in each. Less than 300 persons, including 75 female clerks, are employed by the Western Union Company in its central office in New York, and the average number of messages disposed of daily, exclusive of news messages, is stated to be 24,000. Allowing for the news service, which is stated to amount to about 90,000 words daily, an average of 27,000 messages a day would be attained. Here, in London, as many as 1200 persons, including 700 females, are employed in the Central Telegraph Station. The number of ordinary commercial messages dealt with in a day, allowing for such as have to be retransmitted—*i.e.*, received on one wire and sent out on another—is upwards of 50,000, and taking the news service, exclusive of special wires, at 500,000 words a day, which is a fair average. during the Parliamentary Session a total of more than 70,000 average messages would be reached. The news service is a feature to which very special importance is attached at our Central Telegraph Station. Special wires, known as the "Express Circuits," are set apart for the service, and the Wheatstone system—which, while it economises the wires, largely increases the Staff—is almost exclusively employed. At night, when the great bulk of the news work comes in, as many as forty wires are exclusively occupied in the transmission of matter for the Press throughout the United Kingdom. Nineteen of these wires are leased out to certain provincial newspapers in England, Scotland, and Ireland. The remaining twenty-one are worked to the principal towns of the kingdom, and, taking their united capacity, it would be found that—on a fairly busy night—as many as half a million of words, equal to 250 closely-printed columns of the *Times*, would be disposed of. Besides the clerks employed at the newspaper offices in working the special wires, as many as 200 clerks are employed each night at the Central Telegraph Station between 8 P.M.—when the female Staff leaves duty—and midnight, when the bulk of the news work has generally been disposed of. From midnight until 2 A.M. more than 100 clerks are usually employed; and at no time of the night is the number less than 70. Scarcely, indeed, has the night service of news been completed when the morning service begins, and it would be almost impossible to select any hour out of the twenty-four when Press matter—either in the shape of markets, exchanges, or general news, Reuter, sporting, or Parliamentary—is not passing over the wires.

If the telegraphic system is not yet perfect, it will be granted, at least, that its development thus far has been singularly rapid, and there is, perhaps, no better evidence of this than in the great central offices of London and New York. After all, these immense establishments are but the growth of little more than a quarter of a century; for, as we have seen, it is less than thirty years since a small room in West Strand and another in Wall Street represented the head-quarters of the telegraph systems of the Old World and the New.

THE VOLTAIC BATTERY.

A Course of Six Lectures,

By Dr. JOHN HALL GLADSTONE, F.R.S.,

Fullerian Professor of Chemistry, Royal Institution.

Delivered at the Royal Institution of Great Britain.—Christmas, 1874-5.

Lecture V.

Through the kindness of Prof. Adams, Prof. Armstrong, Mr. Murray, and other friends, there have been lent to me various original forms of galvanic batteries. Some of these I introduced in my last lecture, but there were others which I could not refer to then; and I have thought it well, therefore, to have them put together and placed in the ante-room, upon the table there. You will be interested in looking at them after the lecture. There is, however, one old instrument which I have not put in the ante-room, but have brought upon the table here, and that is this rough-looking electrical apparatus. Now there is not much to admire in its appearance; its interest consists in its history. This is the very electrical machine which Faraday made with his own hands when he was apprenticed to a bookbinder. You may recollect that he was born of honest, good, but very poor parents, and that he was apprenticed early in life. He read some of the books which his master bound or sold, and among them was a copy of the "Encyclopædia Britannica." He read the article "Electricity" in it, and this gave him a great desire to have an electrical machine of his own. Of course, as to buying one, that was out of the question, and so he thought he would make one if he could. And, as I find by the

papers of Sir James South which I have been quite recently looking over, he procured, first of all, a couple of glass vials, for which he gave the amount of sevenpence, and tried to make an electrical machine with them, but failed. He then thought that he must have a real glass cylinder, but even at glass-house price this would cost 4s. 6d.—and how was he to get 4s. 6d.? The summit of his ambition was at that time to get a glass cylinder. Well, at last he saved up 2s., and induced his master, Mr. Riebau, to advance him the other 2s. 6d., to be taken off his wages as time went on. Then he went and bought this cylinder, and he and his father and brother set to work upon it. His father was a journeyman blacksmith, and he made the iron axle that you see there, and passed it through. It is fastened on with corks rather cleverly. And then Faraday dissolved some sealing-wax, which, he said afterwards, was the first chemical experiment he ever performed; and here is the result. You see the sealing-wax with which he insulated the cylinder from the cork. After having placed the sealing-wax—perhaps not very artistically—inside, he covered over the ends of the cylinder with sealing-wax, in order to hide the imperfections of his workmanship. Then as to the stand. There happened to be in his master's cellar an old broken mahogany table, and Faraday got hold of this, cut it into pieces, and made this stand and supports: while a few pence were given to some one to turn the other necessary portions of the apparatus. A piece of silk was obtained, and this rubber was made, and then his brother formed this simple but very effective spring—a brass spring, which keeps the rubber pressing against the cylinder. This prime conductor was also made, which is, as you see, of very simple materials. Unfortunately, it is incomplete; it ought to have a glass stand, but that has disappeared, and so it has been rigged up with this sort of jury-stand at present, in order that it may be in its right position. Then with a handle, which has also disappeared, he was able to turn this cylinder round, and produce sparks and the ordinary phenomena of frictional electricity. Here is an iron clamp, made by his father I have no doubt, by which this machine might be fastened to a table. I thought this would be interesting to you, not only from its connection with the great Prof. Faraday, but also because some of you might like to make your own apparatus; and here you have before you an example from one of the greatest philosophers.

I do not want to say much about frictional electricity, for we are talking about electricity of another kind; but all these electricities are linked together. They are a brotherhood or sisterhood of forces, or, rather, they are the same force manifesting itself in different forms. Frictional electricity will give us, as you know, a spark; and as I have brought here a very old and very venerable instrument, I have also brought one of the latest novelties in electricity. [Exhibiting an American electrical torch.] By moving this knob I can separate these two discs, and in doing so I can produce electricity which manifests itself by a spark. The spark ought to appear in this little cup and ignite the gas. [A jet of gas was ignited several times by the use of the electrical torch.] That pretty little contrivance illustrates the fact that the force is produced by two opposing plates, and by just separating them we are able to get the manifestation of electricity.

Here we have an apparatus—one which is employed for practical purposes—in which two metals are joined together, as in the voltaic pile; but there is no chemical action. They are simply heated at their point of junction. There is a gas flame impinging on the junction of these sets of two metals. The heat acts the same part as the chemical force; it keeps up an electrical difference between the hot and the cold ends, thus allowing of the formation of a current, and I dare say we shall be able to see that it will deflect this magnetic needle just as one of our galvanic cells did. There goes the needle; it flies off just as it would if this apparatus had been a voltaic battery.

Now we can produce electricity also by other means, and one of those most frequently employed is the rotation of magnets. You know very well that a galvanic battery will make a magnet. You have seen that on a large scale. On the large magnet of this Institution we were able to hold very large weights, to build up our bridge of nails, and to make iron filings go into all those beautiful lines of force between the poles which were shown in the first lecture. Well, if we take a magnet we are able from it to produce electricity again,—in fact, an electric current. Many pieces of apparatus have been arranged with that view; but the one I have upon the table is called Gramme's machine. It consists of two sets of magnets, but they are joined together by iron bars, so that, in point of fact, the two north poles are joined, and the bar becomes the north pole of the magnet. The lower ones become the south pole of the magnet. Between these there is an endless coil of wire twisted round and round certain little bars. These little bars communicate with the axle, and if I set it rotating I can get, through this magnet, currents formed in these wires. The current is reversed from the one side of the wires to the other side, so that the one side becomes north and the other south; but it passes gradually from north to south, and the two sides are constantly in opposite conditions. We are able to collect the power by means of these little bars of copper, and carry it off as a stream wherever we please. I will just carry it to this large bell. [An electric bell was rung by means of the Gramme current.] This Gramme's machine will produce a spark. The spark is extremely feeble, and I will not attempt to show it to you all. It can be seen by those who are near at hand. This is only a model of the Gramme's machine as now manufactured. To Sir Charles Wheatstone and Mr. Sabine I am indebted for this. The electric light which is exhibited on the top of the Houses of Parliament during the Session is ignited by means of a Gramme's machine, and they are being prepared now very considerably for electrotyping purposes. I speak of this magneto-electric apparatus more especially, because the current we obtain by means of it is very like the voltaic current. It is not a succession of sparks, but a continuous flow, so that from a magnet we get a current which is almost identical with the current which we get from the voltaic battery.

You will see that in these illustrations which I have given you we have a contact of two bodies. In the electrical machine, the mechanical motion by which we separate them is converted into the

electrical force. In the apparatus which I showed you just now it is heat which keeps up the force. In Gramme's machine we have magnetism and mechanical action producing and sustaining the force. In the galvanic battery we have chemical force initiating it, or, at any rate, keeping it up. In all these cases, therefore, we have various forces which produce very much the same effects. We can produce a spark; we can produce a shock to the nervous system; and we can produce light, heat, chemical decomposition, and so on, by these various means. I do not say that all these forces are identical, but they are all—as I said just now—sisters; they are all related closely one to the other; they are forms of force which are convertible one into the other. The quantity of force does not change, but the form of the force does change, and we may imagine that they are modifications of the first prime force, whatever that may be. Whether we shall ever know more about this prime force I do not know, or whether we should simply consider it as the manifestation of the will of that Great Spirit who is near us all, and "in whom we live and move and have our being."

But there is a difference between the electricity we get from the machine, or the electricity we get from this thermal apparatus, and the electricity we get from our voltaic batteries. No doubt they differ from one another; but then the electricity we get from a galvanic battery is not always the same. We can produce either a very slow, quiet, strong action, or a sudden brisk action, from the galvanic battery. Here is a Grove battery. At present it is arranged in such a way that there is a platinum plate, then there is the zinc joined with another platinum, and so on. So that it goes alternately zinc, platinum, zinc, platinum, and the power accumulates as it goes on through the liquid in this way. Thus we get a voltaic battery of great power, and we can so arrange ten cells, or a hundred cells if we please; or we can arrange—as in the large battery of Davy, or that of Mr. De la Rue—a thousand cells one after the other, and in this way we can get an accumulation of power. I will not go into the mathematics of the question now; but, at any rate, it does happen that we are able to pile up this electromotive force from these different cells in such a way that we get what is called an "intensity" arrangement. We get an exceedingly powerful forward action, and this "intensity" is capable of overcoming serious resistance by going through long spaces of water, bad conducting earth, or coke, or anything of that sort, and by flying across air in sparks; so that it resembles more the electricity that we get from the frictional machine, or the electricity with which Nature furnishes us in that great electrical machine—the thunder-cloud. I am not going into the physical part of the question. I believe Prof. Tyndall intends to exhibit some of these things which are upon the table now, and to enter more fully into the matter, in the course which he has announced. But I should like just to draw your attention to this—that we can have this electricity in different conditions even in the battery; that we can arrange it, as I said just now, accumulating the force so as to get what we call "intensity," and to get this powerful spark; or, on the other hand, we may arrange it so as to produce "quantity." If we take a battery like this,—if we were to take two, or ten, or a hundred, or a thousand cells, and join the platinum to the platinum, and join the zinc to the zinc, we should get only the same effect as from an immensely large zinc plate and an immensely large platinum plate, like the large cell which I put before you in the first lecture. We should get an immense quantity, but little intensity. The electricity would not pass over any space, or any great resistance, and yet the quantity would be enormous. We could do a great deal of electrotyping with it, for instance, and the quantity of electricity we get from this arrangement—even from such a small Grove's cell—is enormous. I have on the table, exhibiting itself quietly, a larger quantity of electricity, I believe, than is displayed in a thunderstorm, and yet it is perfectly under our management here, and I have not the slightest hesitation in handling it. But if this power were disposed in another way, and, instead of appearing as electricity of quantity, it was flowing as electricity of tension, I should be afraid to take hold of the wires.

(To be continued.)

EXPERIMENTS TO ASCERTAIN THE CAUSE OF STRATIFICATION IN ELECTRICAL DISCHARGES IN VACUO.*

By WARREN DE LA RUE, HUGO W. MÜLLER, and WILLIAM SPOTTISWOODE.

SOME results obtained in working with a chloride of silver battery of 1080 cells, in connection with vacuum-tubes, appear to be of sufficient interest to induce us to communicate them to the Society, in anticipation of the more detailed account of an investigation which is now being prosecuted, and which it is intended to continue shortly with a battery of 5000 cells, and possibly with a far greater number.

The battery used up till now consists of 1080 cells, each being formed of a glass tube 6 inches (15·23 c.m.) long and ¾ of an inch (1·9 c.m.) internal diameter: these are closed with a vulcanised rubber stopper (cork), perforated excentrically to permit the insertion of a zinc rod, carefully amalgamated, $\frac{3}{16}$ (0·48 c.m.) of an inch in diameter, and 4·5 inches (11·43 c.m.) long. The other element consists of a flattened silver wire, passing by the side of the cork to the bottom of the tube, and covered—at the upper part above the chloride of silver, and until it passes the stopper—with thin sheet gutta-percha, for insulation, and to protect it from the action of the sulphur in the vulcanised corks: these wires are $\frac{1}{16}$ of an inch (0·16 c.m.) broad and 8 inches (20·32 c.m.) long. In the bottom of the tube is placed 225·25 grains (14·59 grms.) chloride of silver in powder—this constitutes the electrolyte; above the chloride of silver is poured a solution of common salt, containing 25 grms. chloride of sodium to 1 litre (1752 grains to 1 gallon) of water, to within about 1 inch (2·54 c.m.) of the cork. The connection between adjoining cells is made by passing a short piece of india-rubber tube over the zinc rod of one cell, and drawing the silver wire of the next cell through it so as to press against the zinc. The closing of the cells by means of a cork prevents the evaporation of water, and not only avoids this serious inconvenience, but also contributes to the effectiveness of the insulation. The tubes are

* A Paper read before the Royal Society.

grouped in twenties, in a sort of test-tube rack, having four short ebonite feet, and the whole placed in a cabinet 2 ft. 7 ins. (78·74 c.m.) high, 2 ft. 7 ins. wide, and 2 ft. 7 ins. deep, the top being covered with ebonite to facilitate working with the apparatus, which is thus placed on it as an insulated table.

The electromotive force of the battery, as compared with a Daniell's (gravity) battery, was found to be as 1·03 to 1,* its internal resistance 70 ohms per cell; and it evolved 0·214 c.c. (0·0131 cub. in.) mixed gas per minute when passed through a mixture of 1 volume of sulphuric acid and 8 volumes of water, in a voltameter having a resistance of 11 ohms. The striking-distance of 1080 element between copper wire terminals, one turned to a point, the other to a flat surface, in air, is $\frac{1}{263}$ inch (0·096 m.m.) to $\frac{1}{250}$ inch (0·1 m.m.). The greatest distance through which the battery current would pass continuously *in vacuo* was 12 inches (30·48 c.m.) between the terminals in a carbonic acid residual vacuum. This battery has been working since the early part of November, 1874, with practically a constant electromotive force.

Besides 2000 more cells like those just described, we are putting together 2000 cells with the chloride of silver in the form of rods, which are cast on the flattened silver wires, as in a battery described by De la Rue and Müller,† but in other respects similar to the battery above described, the glass tubes being, however, somewhat larger in diameter: the rods of chloride of silver are enclosed in tubes open at the top and bottom, and formed of vegetable parchment, the object of these vegetable parchment cases being to prevent contact between the zinc and chloride of silver rods. The internal resistance of batteries so constructed is only from 2 to 3 ohms per cell, according to the distance of the zinc and chloride of silver rods, and they evolve from 3 to 4·5 c.c. (0·18 to 0·27 cub. inch) per minute, in a voltameter having a resistance of 11 ohms. Their action is remarkably constant.

(To be continued).

Notes.

THE *Faraday* has succeeded in recovering the Direct United States cable, and exchanging signals with Ireland. No official announcement has been made, and consequently there has been a good deal of movement in Atlantic Telegraph shares. It is much to be regretted that information so important to the public should not be issued, and some authoritative announcement made.

At a meeting of the Great Northern Telegraph Company, at Copenhagen, on the 28th ult., the total dividend for the year was announced as being at the rate of 7 per cent, and £12,114 14s. 1d. was added to the reserve fund.

The directors of the German Union Telegraph and Trust Company have issued their Report for the year ending the 1st of May last. The available balance amounts to £12,096 3s. 7d., out of which an interim dividend of 5s. 9d. per share was distributed in January last, and a further payment is now recommended of 7s. per share, making a total distribution of 12s. 9d. per share, or at the rate of £6 7s. 6d. per cent per annum.

A meeting of the Eastern Telegraph Company is summoned for the purpose of sanctioning the acquisition of a convention with the Italian Government respecting a telegraph cable between the Island of Sardinia and the Italian continent.

An interesting experiment has just been carried out at the Indo-European Company's Office, in Telegraph Street, in order to test the accuracy of a new chronometer, made by Messrs. Barraud and Lund, of Cornhill, which was carried out by Capt. Sartorius to Teheran. The line was joined through to Teheran, and time signals sent, thus enabling Teheran to receive Greenwich mean time. The result of the trial, which was most successful, showed that the watch was slow by two seconds.

It is with regret we notice the sudden death of Admiral Sherard Osborn, C.B., who for many years was the Managing Director of the Telegraph Construction and Maintenance Company. To his administrative capacity and his business talents a great amount of the success of that Company must be due. He had retired from the management of that Company some short time since to resume his naval career. It was during his management and under his direction that the greatest works were carried out.

Recently a man fell from the roof of the Pomona Gardens, near Manchester; and fortunately for him his fall was broken by the telegraph wires on the Bridgewater Canal, otherwise he must have been killed, or at all events lamed for life.

An interesting question came before the Queen's Bench as to the rights of *employés* in the telegraph department of railway companies to compensation under the Telegraph Act, 1868. That statute, which enabled the Postmaster-General to acquire, work, and maintain electric telegraphs, authorised him to purchase the undertakings of different companies, and the 8th section of it provided for the compensation of officers or clerks of the companies and undertakings so taken over by the gift of an appointment of equal value, or where no appointment was made by the award of an annuity. In the case before the Court the applicant had been in the employment of the Electric and International Company, and at the same time held the post of telegraph superintendent of two railway companies

* Compared with a Daniell's battery, in which the zinc is immersed in dilute sulphuric acid in a porous cell, its electromotive force is about 3 per cent less than the Daniell.

† "Journal of the Chemical Society," 2nd series, vol. vi., p. 488.

‡ "Comptes Rendus," 1868, p. 794.

In respect of his claim for loss of employment under the Electric, his right to compensation was admitted, but the Postmaster-General disputed any liability in respect of the other employment, and the application was for a *mandamus* to issue from the Queen's Bench to the Postmaster-General to assess the compensation in respect of these losses of services. The Court refused the application on the ground that there was an obvious distinction between the telegraph clerks of telegraph companies and those of railway companies, and that there was no provision in the Act for compensating the railway officials. The distinction lay in the fact that as the telegraph companies were constituted solely for the purpose of sending the messages of the public, the taking over of these undertakings practically extinguished the companies, and that therefore it was only fair that clerks who had been employed by them should be provided with some other occupation or receive money compensation for their loss of service. With the railway companies this was different. The wires and posts remained the property of the companies; they still used and worked them for their own purposes and to manage their own traffic; and so their clerks were not necessarily deprived of employment by the operation of the Act.

One of our young men, of a statistical turn of mind, has discovered, by a careful computation, that if we estimate that each of the sixty young ladies in the City department wears on an average twenty hairpins (and for a *very* curly headed one this is a fearfully small allowance), it would require 600 feet of No. 20 steel wire to equip the whole force,—enough to build an average amateur telegraph line. An ordinary hairpin picked up in the elevator gave a measured resistance of 0·002 ohms. As the magnetic attraction is in all cases inversely as the square of the resistance, it would appear—from theoretical considerations—that the ladies wearing the fewest hairpins would be the most attractive; but experience fails to confirm the absolute infallibility of this law, as many singular anomalies present themselves. A long series of careful observations upon curly-headed girls have fully verified the truth of Dub's law, that "the attraction is proportionate to the square of the number of convolutions," and this fact has served to restore that confidence in the result of scientific study which had previously been in some measure dispelled.—*The Telegrapher.*

Trial is to be made at Portsmouth of a system of signalling by bugle, which has been introduced by Capt. Bamber, Royal Marines, for use in fogs or at night when no signal lantern is available. The plan consists mainly in an adaptation of Morse's telegraphic alphabet to bugle calls, the "long" and "short" being represented by different notes.

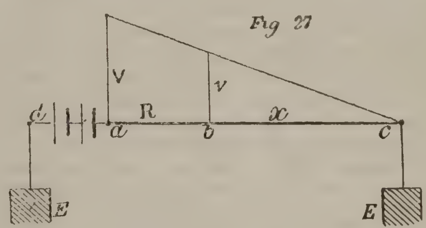
Students' Column.

Resistances and their Measurement. By H. R. Kempe.

(Continued from vol. ii., p. 396.)

XVI. *The Measurement of Resistances by Potential.*—There are two ways of measuring resistances by potential:—1st, by noting the potentials at two or more points in a known resistance with which the unknown resistance is in connection, and by calculation, from the potentials so obtained and the known resistance, deducing the value required. Also by measuring the potential of a battery which is shunted with the unknown resistance, and then reproducing this potential by an adjustable resistance used in the place of the unknown resistance. 2nd, by noting the rate at which a charged condenser, of a known capacity, discharges itself through the unknown resistance, and calculating the result from a formula.

Fig 27



If we connect a battery to a resistance, $R+x$, as shown by Fig. 27, the potential of the battery falls regularly along the resistance, being full at a and zero at c. The same would be the case if c and d were connected together instead of being put to earth. By similar triangles—

$$V : v :: R+x : x,$$

or—

$$x = R\frac{v}{V-v},$$

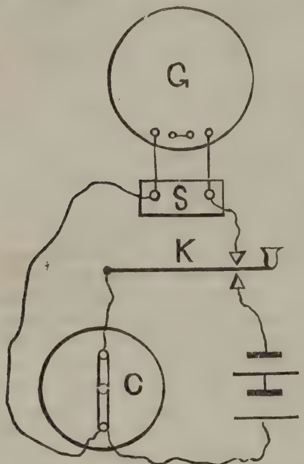
V being the potential at a, and v the potential at b. So that, if R is a known resistance, we can—by noting the potentials at a and b—determine the value of x.

The potentials are best measured by means of a condenser. To do this we should join up our condenser and galvanometer as shown by Fig. 24, which we have before given, the only difference being that the terminals which are represented as being in connection with a battery would, instead thereof, be connected to the points a and d or c for determining V, and to b and d or c for determining v. The condenser discharges in the two cases give V and v. Thus, for example, if R were 1000 ohms, and V were 300° and v 200°, then—

$$x = 1000\ \frac{200^\circ}{300^\circ - 200^\circ} = 2000 \text{ ohms.}$$

If $b\,c$ were a portion of a cable making full earth at c, we should by this method determine the position of the fault.

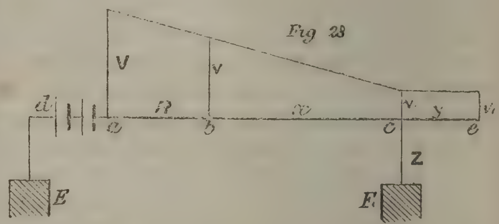
The accuracy with which a resistance can be measured by this method is limited by the accuracy with which the discharge deflections representing V and v can be read. If we cannot be certain of



V or v to within 1 per cent, still less can we be sure of the accuracy of x within 1 per cent. It will be clearly seen that, if V and v do not differ much, a very small error in reading V or v will make a large difference in the value of x calculated by the formula. The same will be the case if v is very much smaller than V. There must, therefore, be some intermediate ratio of v to V which makes any error due to an incorrect reading of v or V a minimum. This ratio is 1 to 2, so that, if we wish for accuracy, theoretically the best plan would be to go on adjusting R until $v=\frac{V}{2}$, which makes x=R. There is, however, a practical difficulty in doing this, for we cannot first note V and then adjust R until $V=\frac{V}{2}$, for the alteration in R will have changed V also. For example, if at starting we found V=300°, and we then adjusted R until v=150°, or one-half 300°, we should probably find that on re-measuring V it would be no longer 300°, but some deflection greater or less than 300°, according as R was increased or diminished. We could, of course, by continual re-adjustment, at last arrive at a value of R which makes $v=\frac{V}{2}$, but this might involve a considerable expenditure of time; so the best proceeding would be to adjust R by large variations until we get V within, say, 10° of the value of $\frac{V}{2}$, and having noted carefully what the exact values are, to calculate x from the formula.

If, instead of introducing the unknown resistance x, and a known resistance R, between the points a and c, and measuring the potentials at a and b, we have only the resistance x, we can determine its value by simply noting V, and then inserting an adjustable resistance in the place of x, and altering it until we obtain the potential V at a, as at first, when of course x=R.

Supposing a cable had a fault which did not make full earth, then the potential would not fall to zero at that point, but would have a value depending upon the resistance of the fault. The potential, however, at the fault would be the same as the tension at the further end of the cable, provided that end were insulated. If we can determine the value of this potential we can readily detect the position of the fault.



Let $a\,e$ be the cable which has a fault at c, the end of the cable at e being insulated. Then—

$$V-v_1 : v-v_1 :: R+v : x;$$

therefore—

$$x(V-v_1)=(R+x)\,(v-v_1);$$

therefore—

$$x=R\,\frac{v-v_1}{V-v}.$$

There would be no difficulty in making this test if the three potentials could be all made in common measure. This could be done if both ends of the cable were at hand; but when a cable is laid this would be impossible, as the potentials at the two ends must be measured with two different galvanometers, and no two galvanometers give exactly the same deflection for the same strength of current, and there is no means of determining what the ratio of one deflection is to the other with the same strength of current. If a satisfactory standard of electromotive force existed there would be no difficulty in doing this, as the discharge deflections from standard condensers charged from standard electromotive forces taken on the two galvanometers would indicate at once the relative value of their deflections.

If the cable is sound when the laying is commenced, a battery put on at one end would charge it to the same potential throughout, when the further end is insulated. Supposing the charging battery to be on board the ship, the electricians there would charge a condenser from the cable and note the discharge deflection obtained. A similar observation would be made at the shore end, and the deflection obtained noted, and the result telegraphed to the ship, which is thus put in possession of the relative value of the deflections of the two galvanometers. During the laying of the 1866 Atlantic cable these deflections were noted by the shore every five minutes, and the result telegraphed to the ship. Supposing the shore obtained a discharge deflection of 300°, whilst the ship obtained one of 200°, when the cable was perfect, then the ship knows that 1° deflection on the shore galvanometer corresponds to $\frac{200°}{300}$ obtained on its own galvanometer: all it has to do, therefore, is to multiply the results given by the shore by this number, to obtain all the results in common measure. An example will illustrate how a test would be applied in practice. Suppose the cable to have a conductor resistance of 800 ohms. The potential at a ob-

tained by the ship is represented by 200° discharge deflection; the shore telegraphs his result as 300°. Now, suppose a fault to occur, the ship will observe that his discharge deflection has sunk, and he notes its value. Let it be 170° (V). He also notes the potential at b, which we will suppose to be 70° (v). The shore telegraphs (which he will be able to do, as the cable is not completely broken down) that his potential is 30°. To convert this to common measure the ship multiplies this number by $\frac{200^\circ}{300^\circ}$, which gives v_1 as 20°. Let R be 1000. Then from the formula we get—

$$x = 1000\,\frac{70^\circ - 20^\circ}{170^\circ - 70^\circ} = 500,$$

showing that the fault is 500 ohms distant from the ship end of the cable. If the length of the cable was, say, 80 miles,—that is, it has a resistance of $\frac{800}{80}$, or 10 ohms per mile,—then the distance of the fault would be $\frac{500}{10}$, or 50 miles from the ship end of the cable.

If a fault, making partial earth, appears in a laid cable, we could localise its position in the following manner:—First, let the further end of the cable be put to earth; note the potential at the nearer end. Next, have the end of the cable insulated, and again note the potential at the nearer end. If we now reproduce these potentials by means of an adjustable resistance, we can find what the resistances were which gave the two potentials in question.

If we call x the resistance up to the fault, y the resistance beyond the fault, and z the resistance of the fault itself, then, in the first case,—

$$r = x + \frac{y\,z}{y+z};$$

second,—

$$r_1 = x + z,$$

and also—

$$L = x + y,$$

where L = the conductivity resistance of the line when perfect. This value is always taken when the cable is first laid.

Then by the formula we gave in Article XII.—

$$x = r - \sqrt{r(r - r_1) + L(r_1 - r)}.$$

The advantage of this method of measuring by potentials would be the rapidity with which the two measurements could be taken. If directions were given that the end of the cable was to be put to earth at a certain time, and then at another given time to be insulated, the first discharge deflection would be taken a few seconds before the time for insulating, and then directly the end is insulated the second discharge reading would be made, and, the deflections being reproduced with the adjustable resistance, the value of x calculated. When the two measurements are made thus rapidly, there would be far less chance of the fault changing its resistance than when the test is made by the ordinary bridge method of measurement, in which each measurement takes a considerable time. The only interval necessary between the two readings in the potential method would be that required to allow the galvanometer needle to return to rest before taking the second discharge.

(To be continued.)

Correspondence.

EARTH-BORING FOR TELEGRAPH POLES.

To the Editor of the Telegraphic Journal.

SIR,—In the hope that it may be interesting to many of your readers, I beg that you will allow me a space in your columns to reply to the arguments used in the discussion following the reading of the paper, before the Society of Telegraph Engineers, by Mr. Gavey, on this subject (reported in your Journal of January 1st). Many of the objections raised to the adoption of this method of fixing poles have arisen from—

The temporary awkwardness which invariably marks the initiation of any new implement or apparatus.

The disposition of ordinary labourers to oppose any innovation which involves the exercise of a little extra physical and mental exertion, until the temporary awkwardness disappears and gives place to that "free and easy" use of the new tool which characterises their accustomed style.

A quicker perception in discovering or anticipating difficulties in a "new" creation than in recognising the more salient points of practical advantage, which can only become apparent in use.

Among the objections raised in the discussion there are, as I hope to be able to show, some that have no real existence, and others that do not outlive the first experiences of the men, while those few which alone may be considered to have any substantial form are, in practice, reduced to such small consequence as to be unworthy of regard when the manifold advantages of the system are properly considered.

Mr. Von Truenfeld observes that there is a certain difficulty in ramming the earth round the pole, which is greatly increased when the pole happens not to be in the centre of the hole. I venture to say that this is quite a mistake: it is proved beyond question that the speedy and successful ramming of a pole in a bored hole is one of the greatest points of advantage, —perhaps the most advantageous of all. When a crooked pole has to be pressed out of its concentricity to obtain a generally upright pitch, I have always found the operation of punning to be rather facilitated: this is somewhat opposed to the experience of Mr. Truenfeld, who adds that in wet clay the difficulties in the way of punning are very great in holes bored, and these are not likely to occur when the holes are dug in the ordinary way. In bored holes, the space to be filled in being so small, our men use the driest surface loam for ramming or otherwise to mix with the wet clay, and thus a sound punning is effected. I have found no difficulty in ramming a pole firm in a bored hole in any soil, but with a hole dug in the ordinary way it is practically impossible to ram a pole firm in wet—or even soft—clay; and this I believe to be very generally known.

I have lately had some experience in putting up lines in South America, over a difficult country, and where it was impossible to obtain any but very inferior labour, and I am able to state that the "borers" were eminently successful. A supply of picks and shovels had been provided, but these were never used, the men preferring the borers to pick and shovel; at the same time it must be admitted that if left to their own selection of tools they would not have used either, but have scraped out the holes with the aid of a piece of iron and a cocoa-nut shell, while working in an easy reclining position.

I did not find that the number of tools to be carried was at all increased; on the contrary, the appliances were fewer in number and more convenient in form,—consisting of one borer, a punner bar, and broad grafting tool, for two men who made the holes and fixed the poles themselves. (The poles were of hard wood, from 20 to 22 feet long by 4 inches minimum

diameter at top, cut in the forest along the line of route.)

I would here observe that Mr. Truenfeld had misunderstood Mr. Gavey with regard to the use of shear-legs and the necessity for carrying a pick and shovel.

The line which formed the subject of reference and figures in Mr. Gavey's paper was an exceptionally heavy one, for accommodating a great number of wires, the weight of each pole varying from 5½ to 10½ cwts., with top fittings to upwards of 50 lbs. The line referred to by Mr. Truenfeld, being for military purposes, would be a light one, and therefore the circumstances were very different.

To use shear-legs for raising small poles which two or three men may carry would be rather ridiculous, and to upraise very heavy poles, with their extra top weight, without the economic aid of light and handy shear-legs (except in certain cases), is, in my humble opinion and experience, equally absurd.

In stating that there are circumstances under which it becomes necessary to carry also a pick and a shovel, the writer, as I understood, had in view those lines in this country which are erected along public and private roads, where at times poles have to be fixed in awkward and difficult places, altogether different to having the open country or a clear line, as in by far the majority of cases; but notwithstanding these occasional restrictions in this country as to the position of poles, it has been found practicable, and also substantially economical, to have no pickaxes on the work under any circumstances.

I take the liberty here to observe that the borers exhibited were not made previous to 1870, and although having the appearance, at first sight, of the ordinary screw-pile or screw-auger, they are quite different, both in form and action, as will be seen upon a closer inspection.

Mr. Graves raises a more practical objection in the labour attendant on the use of the "borers," and I do not find any other difficulty suggested by that gentleman's remarks except that the heavy borers cannot be worked against a wall or fence; but, as Mr. Gavey states, a light borer, with a short handle or ratchet, is highly successful in working in hedge-banks or other difficult places.

In six months' working on public roads, some years ago, in different parts of three counties, it was found that 80 per cent of the holes were bored, this being before the light spoon-borers were used in exceptional places.

Mr. Graves is scarcely correct in taking exception to the amount of ground to be traversed in using the borers, and the damage that might in this way be done to crops.

It rarely happens that poles are erected where crops are growing, and the treading of the men in using a borer is as nothing compared to the excavation of a hole, which at any rate is 4 feet long by 2 feet wide at the top, besides the large superficial area that is covered with the earth thrown out from such a pit, which in shovelling back again causes the grass or crops to be cut away.

The additional labour in using the borer at first is a point of some importance, and in my opinion is the only feature worthy the serious observations of scientific and practical men. Here we have the whole of the difficulty in the true reason that the men avoid using it, while in casting about for excuses for preferring the old method they raise a lot of other objections which are frivolous.

It is certain that if the men, as a rule, "took to the borers" there would be very little to be said against them. It is also a matter of fact that where the men have been disposed to use them they have done so with such extraordinaay success as to make the ordinary method appear an anomaly.

Many years' experience and observation in the use of these implements have convinced me that whenever the men find that they must use the borers, they immediately and instinctively discover how to do so without distressing themselves, and, after getting accustomed to it, prefer the new method. On the other hand, when allowed to do so, they will (to use Mr. Graves's own words) instinctively cling to the spade. This is not very surprising if we consider the matter in its true light, for it is simply the repetition of the old story on the introduction of machinery.

Mr. Graves seems to have given the Spanish spoon a fair trial, but the borers do not appear to have got beyond experimental tests.

The "Spanish spoon" is not a "circular metal disc," as stated in your abridged report on Mr. Gavey's paper, but is only a "third section of a circle" (as in the original paper), and therefore raises the earth, which is previously broken up with a bar, in very small quantities. I need not add to Mr. Gavey's remarks on this point, beyond pointing out that holes made in this manner are largest where they require to be small, and *vice versa*, and to this fact is due most of the difficulty—mentioned by Mr. Graves—in raising the poles: the holes are invariably very much larger at top than at the bottom, sloping downwards on all sides like an inverted cone, and the pole upon being raised finds a footing anywhere, in consequence of which the bank or side of the hole is crushed down from top to bottom. When rammed, the pole in such holes is little, if any, firmer than in those made with pick and shovel.

From Mr. Burton's experience, which coincides with that of Mr. Truenfeld, it would appear that the principal obstacles to the use of the borer are due to the irregular shape of the timber in certain parts, the falling of the earth into the hole, and the serious difficulty in ramming,—points which, being set forth as practical disadvantages, are calculated to create in the minds of persons who have not used these implements an impression which is not quite correct.

Theoretically, a crooked pole put in a hole, not much larger than itself, which is straight, appears contradictory; while practically, it is a very small matter of detail, scarcely noticed.

By shaking or pressing a crooked pole, after it is in the hole, in any particular direction, a few times, the leverage of the pole causes an indent in the side of the hole, which allows the pole to come upright, and also solidifies the bank to the pressure of the wires in cases where an angle occurs.

If the pole is exceedingly crooked the chisel end of the bar is used (after boring the required depth) to slice down a portion of one side of the hole, as required, the earth being removed again with the borer: this is a very insignificant operation, which suggests itself to the men at the time, and forms not the slightest obstacle.

The falling of earth is entirely obviated by placing the punner bar in the hole, point down, against the side opposite to the butt of the pole, which, upon being raised, foots against it and slides down. With very heavy timber, a man puts a shovel there to catch the foot of the pole upon its being raised, and, using it as a lever, causes the pole to slip down immediately. I may observe that, in dug holes, the men use a plank for this purpose when the timber is at all heavy, but all these arrangements are made more to facilitate the raising of the pole than to prevent the falling of earth, which is too slight to be of consequence, unless arising from some very exceptional cause. It must be evident to all who have seen poles erected in bored holes that the pole lodges, or foots, but once,—that when upraised against this footing it drops perpendicularly to the bottom of the hole with considerable force, and thereby crushes itself firmly into the earth.

In reply to Major Malcolm, I beg to state, as a fact, that the V-shaped opening has never in my experience been jammed with stones, nor is there any probability of this occurring. The action with small is precisely the same as with large borers; stones are repeatedly brought up on top of the plate which are "twice the size" of the V-shaped opening: there is no lodgment in this opening for the stone, which is pressed partly into the bank or side of the hole, while the plate passes under it. This, I may point out, is due to the peculiar action of the cutter plate, which is not that of a "screw," but of a "circular plough."

Mr. Culley deals with the subject in a very practical manner, which encourages the hope that the *vis inertiæ* will be overcome in time, as it has been with very many other new appliances. In America it appears, from Mr. Culley's remarks, that the pick and shovel are never used. It is also worthy of note in that gentleman's observations that, in clay, two men bored a hole 5½ feet in thirteen minutes: according to Mr. Gavey's figures (which appear to me to be rather within the mark) it would take one man two hours to do this with pick and shovel,—in addition to which must be considered the filling in, or punning, which in the latter case would occupy three men at least one hour, while in the bored hole two men would accomplish it easily in six or seven minutes.

Replying to Mr. Goldstone, who has found that the borers work successfully on railways while on the flat, I would observe that I have used them repeatedly on embankments and sides of cuttings with success, the difficulty being removed by shovelling the earth from the "upper side" of the spot intended for the pole to the "lower side," thus forming a platform for the men to walk round in turning the borer: this is in hard ground, but in light soil or tipping a light spoon borer may be used by one person only without moving round: this is a great advantage, for, as Mr. Goldstone states, it is very desirable in such cases to disturb the ground as little as possible.

In digging a pit for a pole on an embankment it will be seen that the upper side is always cut away to a great extent before the hole is really formed; therefore it is not extravagant to cut away a smaller amount to facilitate the using of the borer in those cases.

I feel assured that all these points will be readily and quickly mastered by the men themselves whenever the system is once for all adopted and insisted upon.

In concluding this rather long letter, I wish to make a few remarks on the very important points raised in the discussion concerning what are called A poles, in order to show that the opinions there expressed—although formed upon scientific theory—are not borne out in practice.

After no inconsiderable experience with A poles, and having made the experiment, I find that an A pole structure, without a cross bar, or sill-piece, fixed in bored holes, and simply punned in a proper manner, is more effective than a similar structure with the cross bar attached in the large pit dug to receive it in the ordinary way.

The importance of this subject, in an economic point of view, is somewhat startling, for—in addition to the extra cost of the 8-feet cross bar, fitted with strong bolts—the cost of erecting the structure in the "usual manner" is from five to six times greater than with bored holes.

It is well known that A poles generally give way, more or less, to the strain of the wires, and this is invariably allowed for in fixing, by giving the structure a slight pitch in the opposite direction to the strain. Obviously this movement, however slight, has the effect of reducing the tension, and lessens the pressure on the pole by slackening the wires.

In bored holes the structure does not give to the strain of the wires, nor afterwards: this is a result better explained by pointing out the different action that takes place in forcibly uplifting a pole out of a bored hole and out of one made with pick and shovel.

The resistance of a pole to being uplifted is not (as I understand Mr. Bell to have stated) according to the friction of the earth against the sides of the pole, because it is quite impossible to lift a pole out of the hole (bored) after it has been even moderately rammed in. The resistance is in proportion to the weight of earth displaced in lifting, added to the natural cohesion of the particular soil.

In a bored hole it will be found impossible to pull a pole out of its punning, or with its punning out of the space of the original hole. The solid earth will be broken and disturbed at an angle of 45° from the lower centre point of the pole, in every direction upwards. With a pole dug in the ordinary way it is widely different; a large portion of earth having been disturbed, its natural cohesion is destroyed, and is not recovered by ramming: even if compressed into less space, it will not regain its former cohesive power for some years. The space punned is small at the bottom, but on one side of the pole widens upwards in the direction of the angle of pressure, thus offering a yielding or weak side, which gives out in proportion to and direction of the pressure.

In reply to another observation of Mr. Bell, I wish to observe that the depression of 1 foot of an A pole, in bored holes, involves the movement of both poles horizontally in the direction of the strain, which is opposed by the resistance of the natural bank of solid undisturbed earth, which is also intact *between* the two poles.

I venture to hope that this question may form a subject for future experiment.—I am, &c.,

W. A. Marshall.

Electrical Science in English and Foreign Journals.

Comptes Rendus Hebdomadaires des Seances de l'Academie des Sciences. Vol. lxxx., No. 13. April 5, 1875.

A Remarkable Case of Magnetisation.—J. Jamin.—Galileo, in 1607, stated that a stone-magnet in his possession "was so powerful that, on approaching the point of a scimitar to a distance equal to the thickness of a silver piastre, it could not be held back." Also, it was found that "the same pole attracted and repelled the same piece of iron. At a distance of at least 4 or 5 finger-breadths the iron was attracted, but at 1 finger's-breadth distance it was repelled. If the piece of iron was placed on a table, and the magnet put very near it, the iron fled before the magnet as it was made to advance; but if the magnet were withdrawn, at the moment that the intervening distance was 4 fingers'-breadth, the piece of iron followed the magnet." Referring to this singular statement, M. Jamin continues:—In prosecuting my studies I have met a parallel case, but possessing nothing mysterious. I will recall to memory that a bar of steel may be magnetised to saturation by a very energetic current; to one of the halves a southern magnetism may be given, which call *positive*, and which may penetrate to the very core of the bar. Then submit the same bar to an *inverse* current, at first very weak, then increasing, so as to obtain a northern or *negative* magnetism—limited at first to the outer surface, and afterwards penetrating to increasing depths, leaving, however, *positive* layers below it. At the extremity of this bar some of the positive magnetism will penetrate to the outside surface. The observed effect is only the

difference between the actions exerted on the outside by the two superposed magnetisations; for, let the north pole of some other ordinary magnet be now placed at a little distance from the extremity of the magnetised steel, the north pole will be found to act upon its predominating outer and southern layer so as to attract; but on bringing the same extremity nearer the two northern magnetisms (the one on the ordinary magnet, and the other in the core and at the extreme point of the manufactured magnet) act upon each other to the production of a repelling force.

The Quantities of Magnetism and the Situation of the Poles in Slender Needles.—E. Bouty. (Continuation of a former paper.)—The *distance of the poles* from the extremities lessens nearly uniformly as x, the magnetising force increases from zero. The following formula represents this under large limits:—

$$\frac{d}{2} = a\,D\,(1 - p\,x).$$

D = diameter of the needle; d = double the distance of a pole to the nearest extremity; a and p = constants. For very great values of x this formula ceases to be applicable, and d rapidly approaches to a lower limit, $\delta = 2\,a\,D$, which, with the minimum quantity of magnetism L, defines what is called saturation. If we indicate by $\phi(x)$ the permanent magnetising function of the steel employed, the magnetic moment of a needle l long—very great with regard to D—magnetised by a magnetic power x, will be represented by—

$$y = \frac{\omega D^2}{4}\,\phi(x)\,[l - 2aD(1 - p\,x)],$$

whilst, for values of y very close upon its superior limit Y,—

$$Y = \frac{\omega D^2}{4}\,L(l - 2\,a\,D).$$

Repetition of Passage into the Helix.—Continuing this subject,* he says it was interesting to find out whether the increase of the magnetic moment under consideration proceeded from a simple change in the distribution of the magnetism,—that is to say, from a displacement of the poles towards the extremities; or if there was a true increase of the quantity of permanent magnetism retained by the needle. The result of enquiries are satisfactory, for I have found (he says) that the quantity of magnetism and the situation of the poles change at the same time. If the power of x is made to increase from zero, $\frac{A}{A - B}$, the proportion of the quantity of limit magnetism to the quantity corresponding to the first passage decreases and tends towards zero; but it is remarkable that, by means of the curve to represent the magnetising function, if we look for what ought to be the strength x' of the magnetic force to produce the quantity after a single passage into the helix, we find for the proportion $\frac{x'}{x}$ a very sensible constant.

No. 14. April 12, 1875.

E. Pétion sends a memorandum in which he proposes a new means of preserving wood. He proceeds by first submitting the wood to the prolonged action of smoke, and afterwards covering it with a coating of tar-water or of whitewash.

Les Mondes. Vol. xxxvi., No. 11. March 18, 1875.

A proposition to place clock dials at the corners of the most frequented streets, particularly in those places where public clocks are wanting, is to be shortly laid before the French Municipal Council. These clock-dials are to be similar to, but rather smaller than, those seen at railway stations, &c., and are to be placed in front of gas-burners; the mechanism being in electrical communication with the Bourse, they will all correctly record Bourse time.

* "The Magnetisation of Steel." By E. Bouty (Tel. Journ., vol. ii., p. 211).

Les Mondes. Vol. xxxvi., No. 15. April 15, 1875.

Clamond's Thermo-Electric Battery.—H. Logeman.—A letter detailing some experiments made with a small thermo-electric pile, equal in power to two small Bunsen's couples. The experiments illustrate nothing more than what has been several times set forth in earlier numbers of this Journal.

Annales Telegraphiques. Third Series. Vol. ii. January and February, 1875.

The most important articles are—*The Comparison of Insulators* and *Trials of Brooks's Insulators*, a recapitulation of the researches of various electricians, notably M. Gaugain. The perusal of this article, we are informed, will dispense with the necessity of referring to the previous works of M. Gaugain, as regards the trials of Brooks's insulators.

Amongst other articles we notice a long and cleverly written one on *Electric Vote-recording Machines.* This part contains no fewer than seven large folding plates, in addition to several woodcut illustrations.

The traffic receipts of the Great Northern Telegraph Company for the month of April were—this year, 351,662 frs.; last year, 343,158 frs. Total traffic receipts 1st January to 30th April—this year, 1,235,974 frs.; last year, 1,326,066 frs.

The traffic receipts of the Direct Spanish Telegraph Company, Limited, for the month of April (30 days), 1875, were £1494 14s. 6d., against £1475 3s. in March (31 days).

Magnetic Railway Rails.—M. Heyl, engineer of one of the German railways, in a recent report upon the special section under his charge, calls attention to the development of magnetism in the rails. He says: "I have observed that all the rails are transformed at their extremities, after they have been placed in position a few days, into powerful magnets, capable of attracting and of retaining a key or even a heavier piece of metallic iron. These rails preserve their magnetism even after they have been removed, but they lose it gradually. When in position, however, the magnetism is latent, only becoming free when the chairs are removed, and disappearing again when they are replaced. Hence it is necessary to assume that two opposite poles come together at each junction, and that each rail is a magnet, the poles being alternately reversed throughout the line. This production of magnetism in the rails examined is undoubtedly attributable to the running of the trains, and to the shocks, friction, &c., thereby produced. The hypothesis of electric currents, induced or direct, must be rejected, since it is negatived by experiments upon the subject made with suitable apparatus. Although the interest attaching to the fact above stated is at present purely scientific, it is not impossible, says the *Franklin Journal*, that the magnetism thus developed may exercise an influence actually beneficial upon the stability of the roadway, increasing the adherence to the rails and the friction. It is possible, also, that the magnetic currents may be stronger at the moment of the passage of the trains, than either before or after. If this be so, the observations may acquire a still higher practical importance.

To Correspondents.

"Novice" asks.—Why are galvanised iron roofs used on the top of telegraph poles? They are used to keep the damp out of the top of the pole, which would otherwise rot.

THE TELEGRAPHIC JOURNAL.
Vol. III.—No. 56.

LIGHTHOUSES AND TELEGRAPHS.

The fearful wreck of the *Schiller*, on the Scilly Islands, has attracted considerable attention not only to the mode of signalling the arrival of ships, but to the want of communication between outlying rocks and islands with the mainland. It was customary for all American mail steamers to approach the Scilly Islands in order to have their arrival instantly telegraphed to Plymouth and other places, and at night time to announce their approach by firing a gun or guns; but the latter practice has ceased for about two years, owing to the stringent orders issued against it by the Board of Trade, acting under the provisions of the Merchant Shipping Acts. The former practice still remains, and it is apparently owing as much to the desire to sight the Scilly Isles as to the absence of the use of the lead that this frightful disaster has occurred. How far it is advisable for mail and passenger steamers to approach such a dangerous neighbourhood as that of Scilly to impart an hour or two earlier information of their arrival is a matter for the consideration of their owners and navigators. It appears to us that the Lizard is in many respects a far superior point to make. It is safe of approach, the direction of the tidal stream guides the ship up Channel and clear of danger, the lead is a sure guide of position, and a well-equipped signal-station announces arrival.

Mr. Pendarves Vivian, M.P., proposes to call the attention of the proper authorities to the fact that by connecting isolated lighthouses, by telegraph, with the nearest land, many lives may be saved and much suffering at times avoided after a shipwreck has occurred. He instances the *Schiller* as a case in point. From a letter which appeared in a local paper from the chief lighthouse-keeper at the Bishop, it seems that at 11.30 p.m. on the night of the wreck he was called up by his mate and informed that a steamer was on the rocks, her lights being discernible from the gallery. Nothing, however, could be done, as they possessed no means of communication with St. Mary's, where the lifeboat was kept. The following morning, at half-past 6 o'clock, they could see the unfortunate vessel with her rigging full of people; but before 8 o'clock, when assistance reached her, the masts were carried away, and the greater portion of that living mass was engulfed in the heavy ground-sea. It must, Mr. Vivian says, from these facts be apparent that had the means of communication with the lifeboat station at St. Mary's existed assistance would have been afforded soon after midnight, the sea being in no wise too heavy for the lifeboat to do her part. In all probability, therefore, by far the greater portion of those valuable lives would have been saved. He thinks that the question of expense should not stand in the way of the richest and greatest maritime nation in the world, and conceives that after the first cost of laying the cable the cost of maintenance would be trifling. Unfortunately John Bull studies expense as much as one of his meanest tradesmen, and the terrible uproar which has been caused in his Treasury because the postal telegraphs only pay a small dividend on the purchase-money—instead of the handsome dividends paid to the telegraph companies—is an instance how the richest nation in the world is governed by commercial and mercenary principles The cost of connecting rocky outlets with the mainland would be very considerable. Rocky bottoms require strong and massive cables. Strong and massive cables—however strong and massive they may be—are not infallible. Powerful tides, rough seas, rugged shores, rocky bottoms, soon destroy them. Cables will break, and when they do break their repair is very costly. It would cost over one thousand pounds to connect Bishop's lighthouse with St. Mary's. It would cost some hundreds a year to maintain it in working order. Multiply this sum for every lighthouse around our coasts—for there is no reason why one light should be so communicated with more than another—and see what a figure the country would have to pay, and for what? To obtain assistance on rare and very exceptional occasions, when assistance probably cannot be rendered, and on occasions which ought never to arise. Structures which require the aid of abnormal energy to maintain them in working order are very liable to fall into decay when this energy is not constantly exercised. Life-saving apparatus is frequently out of order when wanted. Lighthousemen can work simple telegraph instruments as well as pointsmen and porters on railways. Call-bells—such as those used in fire-engine stations—can be placed in the room of the nearest lifeboat coxswain, or some other authority. But would they be in order when wanted? And if frequent false alarms were raised, to try their efficiency, might not the frequent cry of "wolf" probably cause their failure at the critical moment?

Telegraphy can be placed to no nobler purpose than that of the protection of human life and the alleviation of human suffering. In this proposal to connect our lighthouses with the mainland there is little prospect that such purposes can be effected. There is an absence of that abnormal energy, either commercial or practical, which is required to maintain the communications in order, and there is no absolute proof that if they were in order they would be of any practical use.

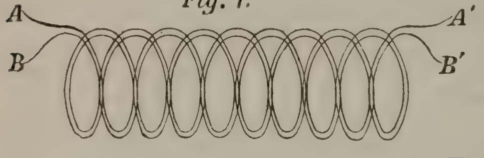
EXPERIMENTS TO ASCERTAIN THE CAUSE OF STRATIFICATION IN ELECTRICAL DISCHARGES IN VACUO.*

By WARREN DE LA RUE, HUGO W. MÜLLER, and WILLIAM SPOTTISWOODE.

(Concluded from page 114.)

For the experiments detailed below, vacuum-tubes were generally used of about $1\frac{1}{2}$ to 2 inches (3·8 to 5 c.m.) in diameter, and from 6 to 8 inches (15·24 to 20·32 c.m.) long; also prolate spheroidal vessels

Fig. 1.



6 inches by 3 inches (15·24 by 7·62 c.m.). The terminals are of various forms, and from 4 inches to 6 inches (10·16 to 15·24 c.m.) apart, and made of aluminium, and occasionally of magnesium and of palladium; the latter showing some curious phenomena with a hydrogen residual vacuum, which will be described in a future paper. A tube which has given the most striking results is 8 inches (20·32 c.m.) long, and has a series of six aluminium rings varying in diameter from ⅜ of an inch to about $1\frac{1}{4}$ of an inch (0·95 to 3·17 c.m.), the thickness of the wire being about $\frac{1}{16}$ (0·16 c.m.) of an inch; the rings are a little more than 1 inch (2·54 c.m.) apart, and connecting wires of platinum pass through the tube from each ring, and permit of the length and other conditions of the discharge being varied.

Fig. 2.

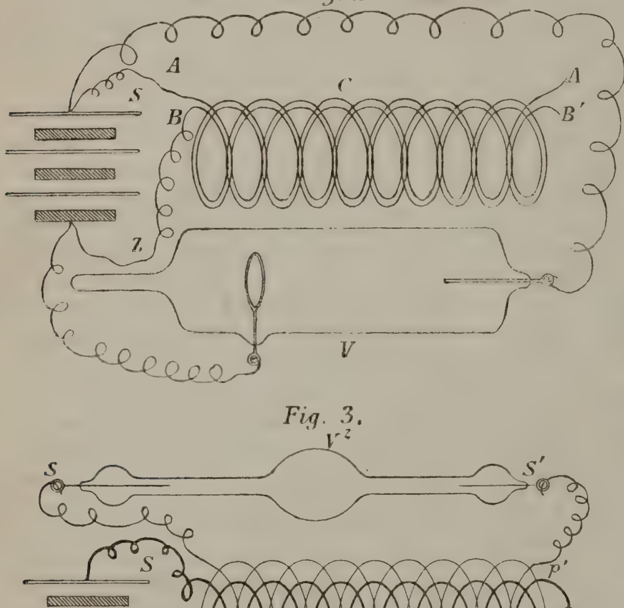
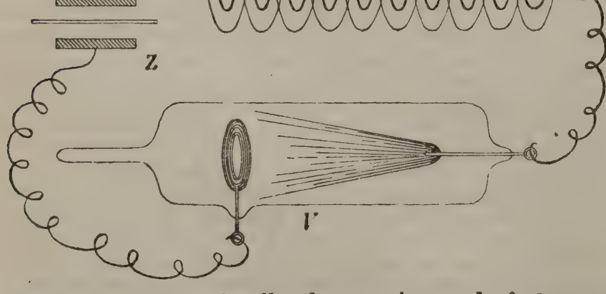


Fig. 3.



At times the terminals of the battery were placed in connection with accumulators of different kinds —for instance, two spheres of 18 inches (45·72 c.m.) in diameter, presenting each a superficies of 7·07 square feet (65·68 square decims.), and cylinders of paper covered with tinfoil, each having a surface of 16 square feet (148 64 square decims.); the globe and cylinders were in all cases carefully insulated. Other accumulators were composed of coils of two copper wires $\frac{1}{16}$ of an inch (0·16 c.m.) in diameter, covered with gutta-percha, in two folds, $\frac{1}{32}$ of an inch (0·08 c.m.) thick. One coil contains two wires, A A′ and B B′ (Fig. 1), coiled side by side, each being 174 yards (159 metres) long; another with two wires, each 350 yards (320 metres) long: of the latter we have two coils.

In addition to these accumulators we have several others formed of alternate plates of tinfoil and insulating material, such as paper saturated with paraffin, and also sheets of vulcanite. These are of various capacities, and contain from 5 to several hundred square feet. The largest has a capacity of 47·5 microfarads; when it is discharged it gives a very bright short spark, accompanied by a loud snap; the charge deflagrates 8 inches (20·32 c.m.) platinum wire, 0·005 inch (0·127 m.m.) in diameter, when it is caused to pass through it. Each accumulator gives different results, but for the present we shall confine ourselves to a description of the experiments made with the coil accumulators.

When the terminals of the battery are connected with the wires of a vacuum-tube which permits of the passage of the current, the wires (especially that connected with the zinc end) become surrounded with a soft nebulous light, in which several concentric layers of different degrees of brilliancy are seen: in most cases there is either no indication of stratification, or only a feeble ill-defined tendency to stratification: the tubes selected for these experiments were those in which the stratification did not appear at all.

When the battery, already in connection with the vacuum-tube, was also joined, as in Fig. 2, on to one or more coil-condensers (coupled to introduce a greater length of wire, then immediately well-defined stratifications appeared in the vacuum-tube.

In Fig. 2 S Z represents the battery, V the vacuum-tube, C the coil-condenser; a terminal is connected with the end A of the wire A A′, and the other

* A Paper read before the Royal Society.

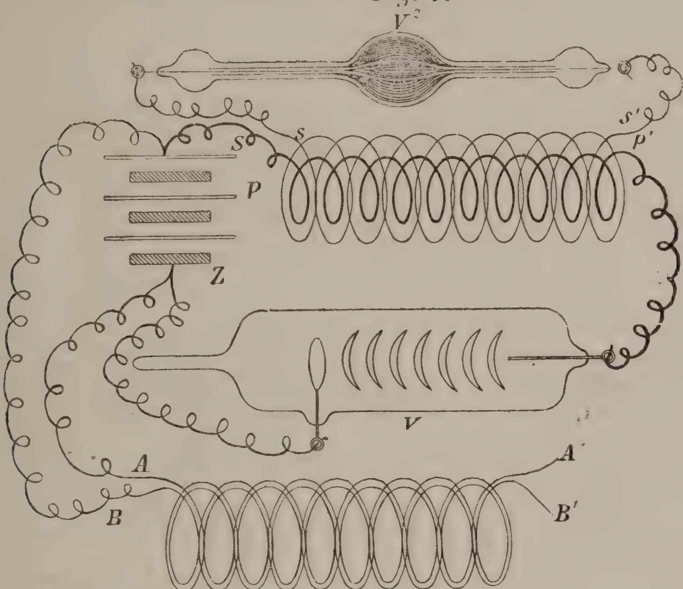
terminal with the end B of the second wire B B′; connections are also led to the wires of the vacuum-tube. The ends A′ and B′ are left free, and it is clear that the coil forms a sort of Leyden jar when thus used: an interval, however short it may be, must elapse in accumulating a charge which at intervals discharges itself and causes a *greater flow* in the vacuum-tube in addition to that which passes continuously. It may be stated that the capacity of the accumulator has to be carefully adjusted to prevent any cessation of the current,—to avoid, in fact, a snapping discharge at distant intervals. The periodic overflows, so to speak, which increase the current from time to time, would seem to have a tendency to cause an interference of the current waves, and to produce nodes of greater resistance in the medium, as evinced by the stratification which becomes apparent. To the eye no pulsation in the current is apparent; and in order to convince ourselves whether or not there was consequently no induced current in the secondary wire, S S′, of the induction-coil.

In the second experiment wires were also led from the terminals of the battery (all other things remaining as before) to the coil accumulator, as in Fig. 4; then, immediately, the discharge in V became stratified, and the secondary vacuum-tube, V^2, lighted up, clearly showing that under these circumstances a fluctuation in the discharge really occurs on the appearance of stratification.

The brilliancy of the discharge in V^2 (the induced current passes through complicated vacuum-tubes through which the primary current cannot pass) depends greatly on the quality and quantity of the discharge in the primary vacuum-tube, V. Under some circumstances the secondary discharge is extremely feeble, and the illumination in V^2 barely visible; under others it is very brilliant.

Preparations are being made to render evident induced currents in the secondary wire of the coil

Fig. 4.



really any fluctuation in the current when the apparatus was thus coupled up with the battery, we made several experiments, and ultimately hit upon the following arrangement:—

The primary wire, $p\,p'$ (Fig. 3), of a small induction-coil, both with and without the iron core, was introduced into the circuit, as well as the vacuum-tube V; to the secondary wire, S S′, of the induction-coil was connected a second vacuum-tube, V^2. Under these circumstances there was no change in the appearance of the discharge in V, in consequence of the introduction of the induction-coil, the terminals being still surrounded by the soft nebulous light before spoken of; no luminosity appeared in the second vacuum-tube, V^2, in connection with the secondary wire of the induction-coil, except on making and breaking the connection with the battery. At other times there was evidently no fluctuation in the continuous discharge, no periodic increase or diminution of flow, and too feeble to produce any illumination. Pending the further development of our investigation, we have ventured to give an account of our progress in elucidating some points in the theory of the vacuum discharge, without any wish to ascribe to our results more weight than they deserve.

Batteries of this description may be had from Messrs. Tisley and Spiller, Brompton Road: their cost, in large numbers, is about one shilling per cell, exclusive of the charge of chloride of silver, which costs about two shillings per cell. The latter, either in the form of powder or of rods cast upon flattened silver wire, may be obtained from Messrs. Johnson and Matthey, Hatton Garden. When the battery is exhausted the reduced silver may be readily re-converted into chloride with scarcely any loss.

THE ROYAL INSTITUTION.

Notes of a Course of Seven Lectures on Electricity.
By Professor Tyndall, LL.D., F.R.S.
February—March, 1875.

(Continued from page 99.)

Notes of Lecture V. *March* 4, 1875.

1. The Leyden jar is thus charged:—The outer coating being connected with the earth, and the inner coating with the electric machine, the electricity poured into the jar acts inductively across the glass upon the outer coating, attracting the opposite electricity, and repelling that of the same name to the earth. Two oppositely electrified layers are thus in presence of each other, being separated merely by the glass. On bringing the inner and outer coatings, by means of a discharger, near each other, before contact is established, discharge occurs in the form of a spark.

2. The escape of the repelled electricity from the outer coating of the jar may be shown by the gold-leaf electroscope, and by various other means.

3. Instead of allowing the repelled electricity of the outer coating to escape to the earth, it may be employed to charge a second jar, while the repelled electricity of this latter may be employed to charge a third jar, and so on. In fact, by insulating a system of jars, and connecting the outer coating of each with the inner coating of the next, the whole series may be charged by means of the electricity communicated to the first. This is Franklin's "Cascade battery."

4. Instead of glass we may employ any other insulator for the jar. Dry air may be employed. Two plates of brass—the one insulated, the other not, with a layer of air between them—constitute a virtual Leyden jar. The arrangement, however, has a name of its own—the "Condenser."

5. In charging the prime conductor of the electric machine the charge on the conductor continues to augment up to a certain point, after which it is not augmented by the further working of the machine. If the electricity be drawn away from the conductor, and stored up in a Leyden jar, it requires a greater amount of turning to reach the stationary point. This withdrawal, or, as it used to be considered, *condensation* of the electricity by the attraction of a layer of opposite electricity, is well shown by the condenser.

6. The condenser consists of two metal plates:—the one, called the collecting plate, insulated; the other, called the condensing plate, uninsulated. The nearer the two plates of the condenser are to each other, the more energetic is the "condensation;" and the thinner the glass of the Leyden jar, the more energetic is the condensation. The force of condensation in the Leyden jar was proved by Wilson and Cavendish to be nearly in the inverse ratio of the thickness of the glass.

7. The Leyden jar is sometimes perforated by the discharge of the electricity through the glass. A certain thickness of glass is necessary to prevent this.

8. The influence of the oppositely attractive coating may be well shown by laying a sheet of tinfoil on a table, a plate of glass on the sheet of tinfoil, and a second sheet of tinfoil upon the glass. All being loose, let the upper sheet of foil be connected with a gold-leaf electroscope, and with an electrical machine: turn the machine carefully till the leaves show signs of divergence; then lift the glass and upper coating by means of silk loops. Removed from the condensing action of the lower sheet of foil, the electricity of the upper one diffuses itself so strongly over the electroscope that, if care be not taken, the ruin of the instrument will be the consequence.

9. Sheets of common block-tin, or even sheets of ordinary foolscap paper unwarmed, may be employed in the last experiment, instead of the sheets of tinfoil.

10. With the principle of induction for our guide we can illustrate in various ways the action of the condenser and of the Leyden jar. Two metal plates, for example, with rounded edges, and with a sheet of vulcanised india-rubber between them, may be made to act as a very powerful Leyden jar.

11. In the first form of the Leyden jar the hand of the operator formed the outer coating, and the water the inner coating. But a complete jar may be formed by two hands, separated by an insulator. Standing, for example, on an insulating stool, with a sheet of vulcanised india-rubber covering my right hand, I clasp with it the left hand of my assistant, who stands on the ground. Laying my left hand upon the conductor of the active electrical machine, my right hand becomes the inner coating, and my assistant's left hand the outer coating, of a Leyden arrangement. On causing the two unclasped hands to touch each other, the "jar" is discharged, and a strong shock is experienced.

12. A spark may be obtained from the clasped hand-jar sufficient to ignite gas, or to fire powder.

13. The duration of the electric spark is very brief: in a special case Sir Charles Wheatstone found it to be 1-24000th of a second; this, however, was the maximum duration. In other cases it was less than the millionth of a second.

14. When a body is illuminated for an instant the image of the body remains upon the retina of the eye for a fraction of a second. If, then, a body in swift motion be illuminated by an instantaneous flash, it will be seen to stand motionless for the fraction of a second at the point where the flash falls upon it. A rifle bullet passing through the air and illuminated by an electric flash would be seen thus motionless; a circle divided into black and white sectors, and rotating so quickly as to cause the sectors to blend to a uniform grey, appears, when illuminated by the electric spark, perfectly motionless, with all its sectors revealed. A falling jet of water, which appears continuous, is resolved by the electric flash into its constituent drops.

15. Owing to its rapidity, the electric spark, in passing through loose gunpowder, fails to ignite the powder, but scatters it mechanically. By the introduction of an imperfect conductor—a wet string, for example—the discharge is retarded, and the powder fired. (The combustion of gun-cotton when detonated is, I am informed, so rapid that magnesium powder mixed with the cotton is unconsumed.)

16. Dry air is an insulator, which must be broken through to produce the electric spark. The comparative ease with which the discharge passes through a partial vacuum has been already, to some extent, illustrated. Through an exhausted glass tube, 6 feet long, a discharge freely passes which would be incompetent to leap over a minute fraction of this interval in air. But whereas the spark in air

is dense and brilliant, the discharge *in vacuo* fills the exhausted tube with a diffuse light.

17. Priestley thus describes the light *in vacuo* :—"Take a tall receiver, very dry, and in the top of it insert with cement a wire not very acutely pointed; then exhaust the receiver, and present the knob of the wire to the conductor, and every spark will pass through the vacuum in a broad stream of light, visible through the whole length of the receiver, be it ever so tall. This stream often divides itself into a variety of beautiful rivulets, which are continually changing their course, uniting and dividing again in the most pleasing manner. If a jar be discharged through this vacuum it gives the appearance of a very dense body of fire, darting directly through the centre of the vacuum without ever touching the sides."

18. Cavendish employed a double barometer-tube, bent into the form of a horse-shoe, with its curved portion empty, to show the passage of electricity through a vacuum. But it is really not the vacuum which conducts the electricity, but the attenuated air and vapour which fill the space above the barometric columns. When the mercury employed is carefully purged of air and moisture by previous boiling, the space above the mercury—as proved by Walsh, De Luc, Morgan, and Davy—is wholly incapable of conducting electricity. I have seen a similar experiment in the laboratory of Mr. Gassiot, to whom we are indebted for so many beautiful electrical experiments.

19. Electricity therefore does not pass through a true vacuum; it requires ponderable matter to carry it. If, moreover, a gold-leaf electroscope be kept at a distance from all conductors, it may be kept charged for an almost indefinite period in a good air-pump vacuum.

20. The matter rendered thus luminous by the electrical discharge is attracted and repelled like other electrified matter. "A finger," says Priestley, "put on the outside of the glass will draw it [the luminous stream] wherever a person pleases. If the vessel be grasped with both hands, every spark is felt like the pulsation of a great artery, and all the fire makes towards the hands. This pulsation is felt at some distance from the receiver; and in the dark a light is seen betwixt the hands and glass."

21. "All this," continues the historian of Electricity, "while the pointed wire is supposed to be electrified positively; if it be electrified negatively the appearance is remarkably different. Instead of streams of fire nothing is seen but one uniform luminous appearance, like a white cloud, or the milky-way on a clear starlight night. It seldom reaches the whole length of the vessel, but is generally only like a lucid ball at the end of the wire.

22. Of the two appearances here described, the former is now known as the *electric brush*, and the latter as the *electric glow*. Both can be produced in air. The glow is sometimes seen on the masts of ships, and it is mentioned by the ancients as appearing on the points of lances. It is called St. Ermo's or St. Elmo's fire, after the sailor's saint, Erasmus, who suffered martyrdom at Gaeta at the beginning of the fourth century.

23. The colour of the diffused light referred to in Note 16 depends upon the residue of attenuated gas, or vapour, through which the discharge passes. If it be an oxygen residue the light is whitish; if it be a hydrogen residue the light is red; if a nitrogen residue the light is purple, exactly resembling the colour displayed at times by the aurora borealis—a colour doubtless due to the discharge of electricity through the attenuated nitrogen of the air.

24. When this electric light is subjected to prismatic analysis it is found to produce, not a continuous spectrum, with the seven colours gradually passing into each other, but a series of separate and distinct bands. At an early period such bands were noticed in the spectrum of the electric spark. They are, for the most part, due to the vapour of the metals between which the spark passes. The spectrum of the electric discharge is often of a very complex character, being in part due to the gas through which the discharge passes, and in part to the incandescent vapour of the electrodes.

25. This vapour and the particles of the electrodes enable an ordinary voltaic current to cross a space which it is quite incompetent to cross when occupied by air.

26. The spectrum bands of incandescent vapours, which are perfectly constant, furnish by their constancy a means of analysis by the prism. Hence has resulted that powerful and far-reaching mode of inquiry called spectrum analysis, which has led to the discovery of new metals, to a secure knowledge of the constitution of the sun and his appendages, and of the nebulæ, comets, and fixed stars.

27. The electric spark produced within a ball of ivory, an orange, or an apple, illuminates the body throughout. Eggs through which the discharge of the Leyden jar is passed are similarly illuminated.

Experiments in Lecture V.

(1.) Leyden jar placed on table; outer coating connected with electroscope: no divergence of leaves when electricity is communicated to the knob.

(2.) Jar placed on india-rubber cloth, with outer coating connected with electroscope: leaves diverge when electricity is communicated to knob. The electricity of the outer coating was here prevented from flowing to the earth, and flowed over the gold leaves. Detach wire, and prove electricity positive.

(3.) Taking oldest form of Leyden jar, with its nail and water, in the left hand: standing on insulating stool, and stretching a lath from the right hand to the electroscope: on electrifying the nail, the gold leaves diverge. As before, the electricity proves positive.

Remark:—A rubbed glass tube amply suffices to communicate to the jar the small charge needed for these experiments.

(4.) The action of Franklin's "cascade battery" referred to in Note 3 was illustrated.

(5.) Bringing the two plates of a condenser close together, but not into contact, and charging gently the insulated plate, which is connected with the electroscope, the leaves diverge slightly. On withdrawing the condensing plate they fly asunder: they fall again when condensing plate is brought near. Divergence and collapse always follow withdrawal and approach of condensing plate.

(6.) Notes 8 and 9 were illustrated. Block tin is very convenient. A plate of glass or a piece of

india-rubber cloth may be used as the insulator. For the block tin, moreover, sheets of common foolscap may be employed. In the actual experiment, the table was covered with paper: a piece of vulcanised rubber, or of glass, was laid on the table, and on it a leaf of foolscap, which was connected by a wire with the electroscope. On electrifying the foolscap, and alternately lifting it and lowering the glass or india-rubber, effects quite as instructive as those produced by the condenser were obtained.

(7.) Charged with the electrical machine instead of the glass tube powerful sparks passed from plate to plate in the experiment referred to in Note 10.

(8.) The action of the Leyden jar formed of the clasped hands referred to in Note 11 was illustrated. A brass rod with a small ball at the end was used to ignite the gas from an Argand burner. The shock at the same time was very smart.

(9.) A circuit was formed between the prime conductor of the machine and the earth, a Leyden jar being included in the circuit. At one place (the focus of a small reflector) the circuit was interrupted, and immediately in front of this focus was the rotating disc referred to in Note 14. On working the machine the jar was periodically discharged; and at every spark the rotating disc appeared for a moment motionless, with all its sectors visible.

(10.) Note 15 was illustrated.

(11.) Note 17 was illustrated.

(12.) The double barometer-tube being connected on the one side with the conductor and on the other with the earth, a feeble gleam of light appeared in the bent portion of the tube when the machine was worked. On introducing a space into the circuit, over which the electricity leaped in a spark, a vivid bow of light, which increased in brilliancy as the spark was lengthened, filled the tube.

(To be continued.)

ON THE FORMS OF EQUIPOTENTIAL CURVES AND SURFACES AND LINES OF ELECTRIC FORCE.*

By W. GRYLLS ADAMS, M.A.,
Professor of Natural Philosophy and Astronomy in King's College, London.

"The paper contains an account of certain experimental verifications of the laws of electrical distribution in space and in a plane conducting sheet."

The potential at any point of an unlimited plane sheet due to a charge of electricity at any other point of the plane at distance r from it is proportional to the logarithm of the distance, and the potential due to two or more charges at different points of the plane is the sum of the potentials due to the several charges, so that when there are two points in a plane conducting sheet connected with the poles of a battery, as there are equal currents flowing at those two points, one into and the other out of the sheet, the potential at any point of the sheet is proportional to the difference of the logarithms of its distances from the two points or electrodes where the current enters and leaves the sheet.

The potential is constant for a series of points if the difference of the logarithms of the distances of each of those points from the electrodes remains constant, *i.e.*, if the ratio of the distances of each of those points from the electrodes remains constant.

The curve joining this series of points is an equipotential curve.

If r and r_1 are the distances of any point in the curve from the two electrodes, and c a constant then—

$$r = cr_1.$$

Hence the equipotential curves are circles with their centres on the line joining the two electrodes; and the lines of force which cut the equipotential curves at right angles are also arcs of circles passing through the two electrodes.

The lines of force may be regarded as distinct from one another, but as filling up all the space on the conductor between the two electrodes; and the distribution would not be altered if we conceive of them as divided from one another like separate wires conducting currents side by side. By taking out any space bounded by lines of force, we shall increase the quantity flowing along the other lines of force, but shall not alter the distribution of the current among them. Hence we may cut out a disc from an unlimited sheet without altering the form of the lines of force, if the boundary of the disc be arcs of circles passing through the two electrodes, so that for a circular disc with the electrodes on the edge of it, the equipotential curves are circles having their centres on the straight line joining the electrodes.

The forms of the equipotential curves may be traced out experimentally by attaching two battery electrodes to a disc of tinfoil, and having two similar electrodes attached to a delicate galvanometer; one of these electrodes being fixed at a point through which the equipotential curve is to be drawn, the other may be moved from point to point to trace out the successive points, so that no current may pass through the galvanometer. A comparison of the experimental results with the theory shows a complete agreement.

In a large square sheet 310 m.m. in diameter, with the electrodes 126 m.m. apart, the curves in the centre and near the electrodes, which are drawn by pricking fine holes through the tinfoil on a sheet of paper below, are very accurately circular, and mostly coincide with circles until the points are so far from the centre that the form of the equipotential curves is affected by the edge of the disc. In a circular disc with the electrodes on the edge subtending 60° at the centre, the experimental curves are shown to be accurately arcs of circles with their centres on the line joining the electrodes.

In an unlimited sheet, when there are several electrodes by which currents enter and leave the sheet, the potential at any point is—

$$A \log \left(\frac{r\ r'\ r''\ \ldots}{r_1 r_1' r_1''\ \ldots} \right),$$

where r, r', r'' . . . are the distances to the electrodes of one kind, and r_1, r_1', r_1'' are the distances to the electrodes of the other kind. Taking the case of one positive electrode at the centre and four

* Abstract of a Paper read before the Royal Society.

negative electrodes round it at the corners of a square, the curves are traced and are seen to be the same as the curves at the corner of a square sheet, with a positive electrode at the corner and two negative electrodes on the edges; the curves are also the same for a square sheet with a positive electrode at the corner, and one negative electrode along the diagonal.

The equation for these equipotential curves is—

$$r^4 = cr_1r_2r_3r_4,$$

and is derived in the case of the limited sheets by considering that to every electrode on the limited sheet there corresponds an equal and like electrode at each of the electrical images of that electrode formed by the edges of the sheet. If we trace the curves for this arrangement of electrodes in the unlimited sheet, the edges of the limited sheet will be some of the lines of force, and so we may divide the sheet along these edges without altering the form of the equipotential curves. Where an electrode and its images coincide in position, the index of r is equal to one more than the number of images.

When there are four electrodes, two of each kind on an unlimited sheet, an equipotential curve is given by the equation—

$$rr' = cr_1r_1'.$$

If the four points lie on a circle, and the complete quadrilateral be drawn through them, the circles which have their centres at the intersections of opposite sides of the quadrilateral, and which cut the first circle at right angles, will also cut one another at right angles. One of these circles is shown to be an equipotential curve for the four electrodes, and the other is a line of force.

Hence, if we cut the unlimited sheet along the edge of this latter circle, we shall not alter the forms of the equipotential curves; and within it we shall have one electrode of each kind, the others being their electric images, the product of the distances of an electrode and its image from the centre being equal to the square of the radius of the disc. If an electrode is at the edge of the disc, then the electrode and its image coincides, and the equation to the equipotential curve is—

$$r^2 = cr_1r_2.$$

When one pole is at the edge and the other is at the centre of a circular disc, since the electric image of the centre is at an infinite distance, the equation to the equipotential curves is—

$$r^2 = cr_1.$$

This is an interesting case, as showing that the equipotential curves do not always cut the edge of the disc at right angles. The curves around the centre of the disc are nearly ellipses of small eccentricity, with one focus in the centre; but on placing one tracing electrode at a distance from the centre—

$$=(3-2\sqrt{2})a,$$

between the electrodes, where a is the radius, there is great uncertainty in determining the form of the curve on the opposite side of the centre of the disc.

This is explained by the fact that the electrodes were 1 m.m. in diameter, and a difference of distance of 1 m.m. between the electrodes near this point corresponds to a large portion of the disc on the other side of the centre; this portion including an area of about 500 square millims. in a circle 36 millims. in radius, *i.e.* about one-eighth of the whole area of the circle. On placing one of the galvanometer-electrodes at the extremity of the diameter through the battery electrodes, and tracing with the other, it is found that the equipotential curve through that point cuts the edge of the disk at an angle of 45°, and that there are two branches cutting one another at right angles.

These peculiarities are explained on tracing the curve—

$$r^2 = 4ar_1$$

corresponding to this case. The extremity of the diameter is a point through which two branches of the curve pass at right angles to one another.

The forms of the equipotential surfaces and lines of force in space may be determined experimentally by taking a large vessel containing a conducting liquid and placing two points, the ends of two covered wires, for battery electrodes at a given depth in the liquid and away from the sides and ends of the vessel, taking similar covered wires immersed to the same depth for galvanometer-electrodes.

For two electrodes the equipotential surfaces will be surfaces of revolution around the straight line joining them, and so will cut any plane drawn through this straight line or axis everywhere at right angles.

Hence we may suppose sections of the liquid made along such planes without altering the forms of the equipotential surfaces. This shows that we may place our battery electrodes at the side of a rectangular box containing the liquid, and with the points only just immersed below the surface of the liquid, and the equipotential surfaces will be the same as if the liquid were of unlimited extent in every direction about the electrodes.

We shall obtain the section of the equipotential surface by taking for galvanometer-electrodes two points in the surface of the liquid, keeping one fixed and tracing out points of equal potential with the other.

The potential at any point in space, due to two equal and opposite electrodes, is—

$$A\left(\frac{1}{r} - \frac{1}{r_1}\right),$$

where r and r_1 are the distances of the point from the electrodes, so that for an equipotential surface—

$$\frac{1}{r} - \frac{1}{r_1} = \text{constant}.$$

These surfaces are cut at right angles by the curves $\cos.\theta - \cos.\phi = c$, which are also the magnetic lines of force, θ and ϕ being the angles which the distances from the electrodes make with the axis. That the lines of force in a vessel of finite size should agree with the lines of force in space, the form of the boundary of the vessel in a plane through the axis should everywhere be a line of force; but the ends of a rectangular vessel coincide very closely with certain lines of force, either when the electrodes are at the ends, or when there are two electrodes within the vessel, and two supposed electrodes at their electrical images at an equal distance outside the ends of the vessel.

The equipotential surfaces are given in this case by the equation—

$$\frac{1}{r}+\frac{1}{r'}-\frac{1}{r_1}-\frac{1}{r'_1}=\text{constant},$$

and the lines of force by the equation—

$$\cos.\,\theta+\cos.\,\theta_1-\cos.\,\phi-\cos.\,\phi_1=c.$$

The curve, for which $c=2$, coincides very closely with the ends of the box.

The equipotential surfaces were traced out in sulphate of copper and in sulphate of zinc by the following method:—

A rectangular box was taken, and the battery electrodes attached to pieces of wood which could be clamped at the centre of the end of the box, and could be brought to any required point in the line joining the middle points of the end of the box. The galvanometer-electrodes were attached to T-pieces which rest on the ends and sides of the box, and the position of the electrodes read off by millimetre-scale placed on the ends and sides of the box.

In the sulphate of copper experiments covered wire with the end exposed was immersed to half the depth of the liquid; in the experiments with sulphate of zinc the zinc electrodes were just immersed below the surface of the liquid. The close coincidence between the experimental curves traced out, and the theoretical curves and surfaces in space is shown by a comparison of the numbers given in the paper for several of the curves which have been traced out; it also shows that, by reversing currents alternately, it is very easy to keep the polarisation very small and of constant amount on the galvanometer electrodes.

When the electrodes are parallel lines extending throughout the depth of the liquid the equipotential surfaces are cylindrical, and their sections are given by the equation—

$$\log.\,(r r' \ldots)-\log.\,(r_1 r_1' \ldots)=\log.\,c,$$

where there are several positive and several negative electrodes, $r.r'$ . . ., &c., being measured from the points where the electrodes cut the plane of the section.

Hence the forms of these equipotential curves are the same as in a plane sheet, so that the forms traced out in tinfoil will be the same as the corresponding forms in space for line electrodes. These forms may be traced out in sulphate of copper with copper electrodes, or in sulphate of zinc with amalgamated zinc electrodes, and for these experiments with cylindrical and other vessels, the polar coordinates may be measured directly. One of the battery electrodes is mades the origin of coordinates, and a lath or brass wire resting on the edges of the vessel has a slot along it, the origin being at one end of or at some point of the slot. In the slot is a sliding piece of wood or ivory which carries one of the galvanometer-electrodes, and the lath is capable of turning about the battery electrode on which it is placed. Around this electrode is a graduated circle for measuring the angles about the origin, and on the sides of the slot is a millimetre-scale for measuring the distances from the origin.

The other galvanometer-electrode may be fixed in a manner which is most suitable in each case.

The result of these investigations show how closely the experimental determination of equipotential surfaces and lines of force agrees with the theory of electrical distribution in space.

OPEN AND CLOSED CIRCUITS.

The following reply to "Inquirer" has appeared in a recent number of the New York *Journal of the Telegraph*:—

"The writer asks, in reference to certain statements, and citing the English preference of the open and the American for closed circuits, Which is correct? We answer—Both, but with the advantage apparently in favour of the American system. It is undoubtedly true that osmotic action and exosmotic action, which really mean the same thing, are aided by the current. It is equally true that with a closed circuit the action of the zinc element is in excess of the copper element, the exosmosis of which it holds in check. It is also true that an open circuit, too long continued, leads to such a deposit of copper on the zinc as to reduce action of the latter, and consequent waste of material and decrease of power. Thus both the open and the closed circuits have their losses and values. The problem, after all, is what amount of alternately open and closed circuits contribute most to the preservation of constancy, and economic and equal action of the battery elements. We do not believe that there is a margin of advantage in either case, so far as constancy is concerned, from which to prove very marked superiority, yet it would be a useful subject of investigation to determine the actual rates of consumption under the two systems. The apparent advantage of the American plan is in the fact that main batteries are only needed at terminal offices, while the open circuit system requires them at all stations."

With further reference to the subject, we believe that one great argument against the use of the "closed circuit" principle is that it rapidly destroys under-ground work. In America—where the use of covered work is very limited—this objection does not exist; but in England—where every large town has an extensive mileage of underground work—the destruction of the gutta-percha insulator would be a serious matter.

To us it appears that the great advantage of a "closed circuit" lies in the fact that it—in consequence of the battery power remaining fairly equal throughout, and the current fairly constant at each station whichever station on a crowded circuit is working—obviates all that troublesome adjustment necessary where the "open circuit" principle is in force, when the circuit has upon it more than two offices. Whether, however, this is compensated by the evident influence the constant current exercises upon the gutta-percha under-ground work is a question for consideration, and no doubt it is one which will have to be governed very much by local circumstances.

Post-Office Telegraphs.—Statement showing the total number of messages forwarded from Postal Telegraph Stations in the United Kingdom during the week ended the 15th May, 1875, and during the corresponding week of 1874:—1875, 406,574; 1874, 375,524; increase in the week of 1875 on that of 1874, 31,050.—Week ended 22nd May, 1875, and corresponding week of 1874:—1875, 386,773; 1874, 365,452; increase in the week of 1875 on that of 1874, 21,321.

Notes.

It appears that in the Arctic Expedition "Electricity" will not be forgotten, for experiments are to be made with regard to the electrical state of the atmosphere. Sir William Thomson supplies his well-known portable "electrometer," and other instruments will be used. Spectroscopes are provided for observation of the aurora; and the employment of batteries for obtaining comparison spectra being out of the question, a Gramme machine has been provided to produce the necessary current of electricity.

The Post-Office Submarine Telegraph stores, at Lowestoft, were destroyed by fire on the eve of the Derby. The flames spread with great rapidity, and the building—which was 300 feet in length—was destroyed, together with a quantity of paraffin, paint, and other oils, and a number of rockets. The total damage caused by the fire is estimated at £18,000, including a quantity of submarine cable. The contents, to the extent of £14,000, were insured in the Sun Office.

The manufacture of the new cable for the Western Union Telegraph Company, from Punta Rana to Key West, is being carried on at the India-rubber Company's Works, at Silvertown.

The Anglo-American Telegraph Company have introduced a word-tariff since May 1st, and, though the effect of the reduction has not yet proved successful, there can be no doubt that it is a step in the right direction. The price varies from 1s. 6d. to Newfoundland to 3s. 6d. to Vancouver Island. It is 2s. to New York, 2s. 6d. to California, per word.

The fifth International Telegraph Conference, which is on this occasion to be held at St. Petersburg, assembles on the 1st inst. Representatives from all countries and foreign telegraphic administrations will be present, the British Postal Telegraph Department being represented by Mr. H. C. Fischer, the Controller of the Central Telegraph Station in London, and Mr. Alan E. Chambre, the Surveyor of the Private Wire Branch of the Department. Colonel Robinson with Major Bateman represent the Indian Telegraph Department; Sir James Anderson and Mr. Lewis Wells (formerly of the Electric and International Telegraph Company) the Eastern Telegraph Company; Sir James Carmichael and Mr. S. M. Clare the Submarine Company; Mr. Andrews the Indo-European Company; and Mr. H. G. Erichsen the Great Northern Company. The principal business of the Conference will be the codification of regulations arrived at on previous meetings, so as to secure some uniformity in the treatment of international telegrams. An important proposition, having for its object the reduction of the *minimum* number of words in foreign-European messages from 20 to 10, and a corresponding reduction of the tariff for such messages, will be brought forward; and the attention of the Conference will be asked to a somewhat similar proposition with regard to extra-European messages. The sittings of the Conference will, it is anticipated, extend over a period of six weeks.

The annual general meeting of the Great Northern Telegraph Company took place at Copenhagen on the 28th of April. Count Sponneck presided. During the past year no extensions of the European cables have been made, efforts having been confined to thoroughly consolidating the undertaking, and otherwise utilising the resources at the Company's disposal. Two cables had been broken, one of which (France and Denmark) had only recently been repaired. All cables were now in a most satisfactory state. The Danish Government lines had been improved and rebuilt. Sir William Thomson's recorder was the instrument now employed on all lines between England, Denmark, and Russia, and the speed had thereby been considerably increased. The European traffic statistics show an increase of 27 per cent on the 1873 work, viz.:—

			Francs.
1874.—722,386 messages,	value		2,332,568
1873.—536,206	,,	,,	1,840,496
	Increase	... ...	492,072

A school for theoretical and practical education had been established at Taborg, near Copenhagen, and a pension fund for the Staff of the Company started. It now counted 150 members, who contribute 3 per cent of their salaries, and the Company a like amount. Interruptions to the China and Japan cables had been few compared to the previous year. The land lines were in good condition, and extensions in China were being cultivated. The increase of traffic over this section of the Company's system, as compared with 1873, equalled 38 per cent. The dividend for the year was fixed at 7 per cent, Mr. O. B. Suhr being re-elected as a Director, and Admiral Bille and Mr. Berner as Auditors.

From the Annual Report of the Atlantic and Pacific Telegraph Company we learn that its system now covers, 14,612 miles of poles, and 28,477 miles of wire, serving 1385 offices. During the year new lines had been constructed to the extent of 728¼ miles. The gross receipts were 450,534·01 dols., and the gross expenses 399,111·97 dols., leaving a net profit of 51,422·04 dols. Exclusive

use of Sir Charles Wheatstone's automatic system of transmission in the United States and the Island of Cuba had been purchased, and important extensions—by which the Company's system will embrace all the leading cities north and south—are under consideration, with the prospect of favourable results. The reduced rates, which took effect on the 15th of February, resulted in an immediate increase of business quite equal to the Company's expectations. Further reductions are contemplated as soon as the increase of wires and manufacture of automatic apparatus will admit of a proper discharge of the contemplated increase.

The *Journal of the Telegraph* publishes, as an extract from the *Albany Evening Journal*, a description of an iron telegraph-pole which is now being manufactured for use in New York. It is stated to be lighter than a wooden pole of the same height, far stronger, and capable of supporting a much greater weight. Its construction is that of a number of wrought-iron bars, rolled out the entire length of the pole, which bars are placed around light cast-iron cores, arranged at proper intervals from each other. The cores have seats or notches to hold the bars in their places, so as to prevent their moving sideways, and the bars also have notches into which the cores fit, to keep them from moving up or down. Around the outside, where each core is placed, a ring or band of wrought-iron is tightly fitted, which holds the bars firmly in their places. Any number or any sized bars may be used, but it is found that six very light bars of angle iron arranged in this way afford a strength equal to that required for a pole 50 feet in height. The cores are larger at the base than at the top. No machinery or shop labour is required to put it together other than the making of the outside rings, so that a pole may be ordered in pieces and put together at the point where it is to be used.

A Bill introduced into the New York State Assembly, to compel telegraph companies to put their wires underground in the cities of New York and Brooklyn, has been thrown out by the Committee on Cities and Villages, to which it was referred. The Committee, after repeated hearings, by a unanimous vote decided not to report it.

Proceedings of Societies.

SOCIETY OF TELEGRAPH ENGINEERS.

At the ordinary meeting on Wednesday, 10th March, Mr. LATIMER CLARK, President, in the chair,

The paper read was "*On Batteries and their Employment in Telegraphy*," by JAMES SIVEWRIGHT, M.A., Associate. After stating that it was not his intention to enter into the history of the battery, the author proceeded to a brief review of the rival contact and chemical theories which had been advanced to account for the action observed in the galvanic or voltaic cell.

Having shown that the former was in direct opposition to the principle of the conservation of energy, and that the more delicate testing apparatus invented since Faraday's time had demonstrated the latter to be untenable, he explained the latest theory which had been put forward. This reconciles to some extent the previous theories, for it allows on the one hand, to the supporters of the contact theory, that the initial action is due to the simple contact of dissimilar bodies, whilst on the other hand it asserts that this action can be maintained only by chemism. The weak point of this, however, as well as of the old contact theory, was stated to be the difficulty in accounting for the initial action. For, recognising the universal truth of the principle of the conservation of energy, that it is an absolute impossibility to create force *de novo* without the transmutation of an equivalent from some other form, it is difficult to see how the simple contact of two dissimilar bodies can of itself call into play any novel form of energy. Experiment, too, it would seem, can bring but little assistance to a satisfactory solution of the difficulty, that so far as one can judge at present must be left to the scientific imagination.

Having pointed out the deleterious effects of *galvanic polarisation* and *local action*, to one or other of which all batteries are more or less subject, the author proceeds to state the conditions which, in his opinion, should be fulfilled by a perfect battery for actual every-day use. They are three in number, and are as follows:—

(1.) That the current obtained from it should be constant.

(2.) When the battery is not actually required, there should be no action going on in it attended by a needless consumption material.

(3.) The materials employed in its construction and maintenance should not be expensive, or, at all events, should be as inexpensive as possible, and there should be no difficulty or danger in handling them.

The Daniell is selected as the first battery for examination, not more on account of the time-honoured position which it occupies, than from the fact that in one or other of its numerous modifications it is more widely employed than any other.

After describing the principle of Daniell's battery, and the mechanism of the "ordinary" form which is in general use in England, the author observed that this battery fulfilled more than any other, the first condition, viz., that of constancy; but that as regards the second, it fell far short of the ideal battery. Unnecessary waste of materials is constantly going on in it by reason of "osmose" and the diffusion of the two liquids—solutions of copper sulphate and zinc sulphate—which are employed, and the amount of real work done is thus out of all proportion to the materials consumed. With the object of surmounting this evil, which is inherent in all forms of two fluid batteries, M. Leclanché introduced the battery which bears his name. This, although admitted to be superior to all the single fluid batteries hitherto tried, was stated to labour under some, at least, of the disadvantages to which they are subject. Constancy is not to be found in the battery when it is incessantly worked for any length of time: the variation in the strength of current is attributed—first, to the unconsumed hydrogen accumulating in the negative element, and the giving rise to galvanic polarisation; secondly, to the formation of double salts—oxychlorides and zinc ammonic chlorides—which

being slowly soluble, interpose additional internal resistance in the path of the current.

Although inferior to Daniell's battery in the matter of constancy, the Leclanché possesses a decided advantage over any other battery which has hitherto been tried so far as the second condition is concerned. No unnecessary waste can take place from either osmose or diffusion. The defects when the battery was at rest lay in the corrosive action which takes place at the point where the connecting wire is united to the negative element; the destruction of the connecting wire by the fumes of free ammonia given off in the action of the battery, and the formation of white-lead. The first two, it was pointed out, had been got rid of to a great extent by the introduction of the trough form of Leclanché, but the last-named had not thus far been eradicated. Still the main difficulty and the chief item of expense in the maintenance of this battery, it was urged, is the porous pot or partition. Whether in the earlier or later form these crack or flake, owing to the formation of the double salts, whose influence as they pass from a state of solution into the solid form cannot be resisted. This and the galvanic polarisation disqualify Leclanché's battery from being used where a heavy strain is to be placed upon it: it is thus unsuited for a "local," and cannot be relied upon for the maintenance of a constant current.

To obviate the necessity of having a porous partition at all in Daniell's battery, the "gravity" form of battery was introduced: in this the liquids are kept apart by the force of gravity alone. The Minotto, one of the best known of the class, is universally employed in India, as well as for some special purposes in England, and has given universal satisfaction.

Grove's battery, it is stated, possesses none of the qualifications which a battery intended for general use in telegraphy should possess. The current obtained from it is not constant for any length of time: there is a vigorous chemical action attended with unnecessary waste going on even when the battery is at rest, and the materials employed in it are both expensive and difficult to handle. Notwithstanding all this, Grove's battery was largely employed until quite recently in America. So also was the carbon or electropoion battery, which differed from the Grove in having a plate of carbon immersed in a solution of bichromate of potash as the negative element in place of a plate of platinum in concentrated nitric acid. Both of them are now fast disappearing in favour of one of the numerous forms of gravity battery, the Callaud, the Hill, the Lockwood, the Baltimore.

The Callaud, which is a gravity battery pure and simple, is that which is coming into most extensive use in America. Complete rest, so as to prevent the mixture of the two liquids, is essential in it as in all similar forms of gravity batteries for efficient working. When this is ensured, the Callaud appears to do satisfactorily what is required of it.

The special feature of the Lockwood is the arrangement of the negative element. It consists of two concentric coils of coppered wire, and an upright standard formed of a straight piece of heavy copper wire provided with nuts and washers at each end. These coils are wound in reverse directions, and "the influence of the electric current passing through the coils when the battery is at work, is such as to keep the two solutions apart," according to the statement made by the proprietors of the battery. Whether there is any special virtue or not in this arrangement of the copper plate, the author was not at present prepared to say.

After a brief allusion to the Baltimore battery, and the form manufactured by Messrs. Siemens and Halske, the author concluded by saying that the perfect battery for universal use—if anything in connection with telegraphy will ever be accounted perfect—is still a thing of the future, and must, when it eventually does make its appearance, realise on the one hand the principle aimed at by Leclanché of giving in the work done a complete equivalent for the materials consumed, and inspire on the other hand the perfect confidence of the Daniell in being equal to any emergency, and ever ready to respond to whatever demands are made upon it.

The discussion on this interesting paper was adjourned, and resumed on the 24th March; it again occupied the whole attention of the meetings on the 14th and 28th April, when it was finally brought to a close. The paper and discussion certainly form the most important of any yet brought before the Society, and regret is felt that space cannot be given to a full report of the discussion. The paper was commented upon by several well-known gentlemen. Mr. C. V. Walker entered carefully into the relative cost of graphite and other batteries. Mr. Hawkins gave interesting details of the Leclanché battery. Mr. Alfred Bennett read some interesting statements relative to numerous experiments with regard to new forms of batteries. Dr. John Hall Gladstone spoke at some length upon the general question; whilst Mr. E. Graves gave expression of sundry practical results obtained in the Post Office. Mr. Higgins dealt with batteries for requirements of large quantity, and explained those used by the Exchange Company; he also explained and showed in action the "Clamond Thermo-Electric pile" (of which we shall give our readers a separate description). Mr. Alfred Smee, F.R.S., gave interesting particulars of the well-known platinum-zinc battery. Dr. Siemens furnished further communication. Mr. Preece entered into minute detail of the theory and action of such forms of batteries as are in use by the Government, and drew especial attention to the difficult nature of electrical nomenclature as at present adopted. Mr. Warren De la Rue showed his chloride of silver battery of 1000 elements, and with the aid of condensers and vacuum tubes exhibited various experiments on the stratification of light. The discussion, after a reply from the author, was brought to a close with some able remarks from the President.

METEOROLOGICAL SOCIETY.

At the last meeting of the Meteorological Society, on Wednesday evening, May 19th, a paper was read by the President, Dr. Mann, "*On some Practical Points Connected with the Construction of Lightning Conductors.*" The paper dealt especially with the material and dimensions of conductors, the nature and influence of points, the essentials of earth-contacts, connection with metallic masses forming a part of the construction of buildings, the power of induction in producing return shocks, the dangerous action of metal chimney pots upon unprotected chimney shafts, and the facility with which houses may be efficiently protected when the defence is made part of the original design of the architect. The conditions which were finally insisted upon as indispensable to efficiency of protection were—1. Ample dimension and unbroken continuity in the lightning rod. 2. Large and free earth contacts, with frequent examination by galvanometers if the condition of these so prove that they are not in process of impairment through the operation of chemical erosion. 3. The employment of sufficient points above to dominate all parts of the building. 4. The addition of terminal points to the conducting cistern wherever any part of the structure of the building comes near to the limiting surface of a conical space having the main point of the conductor for its height, and a

breadth equal to twice the height of that point from the earth for the diameter of its base. 5. The avoidance of all less elevated conducting divergencies within striking distance of the conductor, and especially of such dangerous divergencies of this character as gas-pipes connected with the general mains, and therefore forming good earth-contacts.

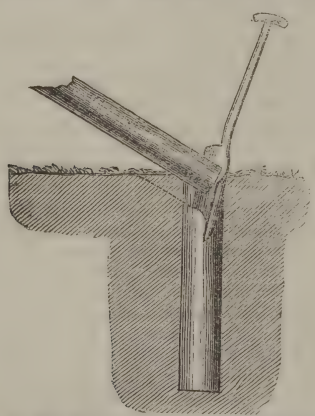
Correspondence.

EARTH-BORING FOR TELEGRAPH POLES.

To the Editor of the Telegraphic Journal.

SIR,—Reading in the TELEGRAPHIC JOURNAL of the 1st of January a discussion on the merits of post-hole borers, and having had some experience in the construction of telegraph lines in South America,—moreover as my experience is totally at variance with Mr. Burton's and Mr. Truenfeld's,—I hasten to give it to you. I agree perfectly with Mr. Gavey in the advantages of the borer. I have used the ordinary American borer, and consider it an indispensable tool in telegraph construction in this country. In the province of Buenos Ayres, where there is neither gravel nor stone of any kind (except at a few isolated spots in Tandil, in the far south, where telegraphs or railways have not yet reached), the borer can be used with great advantage. In Entre Rios and Corrientes you find gravel-hills, and loose stone occasionally, and have to use a chisel-bar to loosen it; but there are places all over the country where it would be impossible to secure a pole firmly without a borer—in Banados, or low swampy places. As to the men objecting to carry extra tools, those who have once used the borer eagerly ask for it again; besides, the man who carries the borer carries nothing else, his companion carrying spade and bar if required—pick and shovel are never used.

I have had no difficulty in boring holes making an angle of 60° with the surface, on railway curves where the poles require to be canted, nor have I seen any poles so crooked that I could not fix them with the borer. As for the earth being pushed down into the hole in erecting the pole, any intelligent workman can prevent that with the rounded spades used in this country (see Fig.). One man holds the spade with the



blade half in the hole, to receive the thrust of butt of pole and prevent it running into the earth while the others are lifting it. As Mr. Gavey remarks,—"The smallness of the space between pole and ground is one of the great advantages of a bored hole," particularly in wet soil, where, if the hole is dug with spade and shovel, no amount of ramming will secure a pole without stones, which may not be at hand: with a bored hole any flat stick or batten will do to ram the small space between pole and ground, and poles put up in bored holes I have found firmer than any others. In case a pole is heavier than usual it is only necessary to scoop away a little earth from edge of hole, as shown by dotted lines in sketch.

In a line 155 kilometres in length, passing through a country diversified with gravel-hills, swamp, soft loam, tough clay, and sandy soil, and put up by two gangs of fourteen and sixteen men respectively, the smaller gang had two borers between them; the larger gang, for want of borers, used the rounded spade, a bar, and scoop. The following is the proportion of work done by each gang:—

Small gang, with borers..	..	13 parts
Large gang, with spades	..	7 ,,

The small gang used scoop, spade, and bar, as well as large gang in the hard ground.—I am, &c.,

J. H. BLOOMFIELD,
East Argentine Railway.

Concordia, Entre Rios, Republica Argentina,
March 25, 1875.

Electrical Science in English and Foreign Journals.

Comptes Rendus Hebdomadaires des Seances de l'Academie des Sciences. Vol. lxxx., No. 15. April 19, 1875.

The Theory of the Process of Magnetisation.—J. M. Gaugain.—This is so bound up with other papers, from the same author, on the subject of magnetism, that we have not room to spare in our columns to intelligibly abstract it. We therefore refer our readers to the original paper.

A New Source of Magnetism.—Donato Tommasi.—When a current of steam, subject to a pressure of 5 to 6 atmospheres, is passed through a copper tube measuring 2 to 3 m.m. in diameter, and covered with a helix around an iron cylinder, the cylinder becomes magnetised so that an iron needle situated some centimetres distant from the *vapour magnet* is energetically attracted, and remains magnetised during the whole time of the steam-current's passage through the copper tube.

Bulletino Telegrafico. Anno xi. March, 1875.

An agreement has been entered into with the "Erlanger" Company to lay and maintain a submarine cable from the Italian mainland to the island of Sardinia.

The *Perseveranza* gives a description of the monument erected, at Camnago, in honour of Volta.

Volpicelli read a paper before the Accademia dei Lincei, on the 14th of February, on Melloni's theory of electrostatic induction, which, he argued, was preferable to that commonly adopted.

A new International Telegraphic Conference will be opened at St. Petersburg in the course of June. The proposal for the neutralisation of telegraphic lines will be abandoned, since the great powers are not disposed to give it their adhesion.

New Use of Platinum.—La Revue Britannique announces that George Robinson, of New York, has invented a new process for sawing all woods with the greatest ease. Instead of a saw he uses a thin platinum wire, heated to whiteness by the continuous passage of an electric current.

To Correspondents.

G. E. S.—We shall be happy to insert a scientific explanation of your battery. In its present form your communication is too much of an advertisement.

We have duly received Mr. LEMON'S communications from New Zealand.

MR. EDWARDS.—We have not the information you require.

THE TELEGRAPHIC JOURNAL.
VOL. III.—No. 57.

TELEGRAPHIC FINANCE.

THE customary capital account presented to Parliament by the Comptroller and Auditor-General has afforded one of our daily contemporaries a further opportunity of carping at the telegraph expenditure of the Post-Office. It seems high time that the public mind should be directed to the true issues of the question. The administrators of our telegraph system are precluded from defending their own acts in the public press, and the discussion of a purely financial question of this character, scarcely falls within the scope of the columns of a technical journal. Nevertheless, there are certain general facts so patent that he who runs may read. *Ex parte* statements only have hitherto appeared. The debtor side of the account has been shown, but not one word has been said of the creditor side. It may be true that the revenue has fallen short by over £100,000 of the amount required to pay interest on the capital borrowed, but what have the public benefitted by this expenditure? Does the public itself complain? We have carefully examined this report, and we fail to perceive any error committed, any defect of administration exhibited, or any evidence of "lavish magnificence." £584 4s. 2d. was relinquished "as a compromise in settlement of all claims on the other side." It is not suggested that this was improper or extravagant, but that it was done "without even taking the trouble to refer to the Treasury for advice or permission."

The Report of the Auditor-General is presented to Parliament annually, pursuant to a recent Act. It is, however, regarded by the public generally as some exceptional document called forth by persistent *laches* on the part of the Post-Office Telegraph Department. It is no such thing. The Auditor-General is compelled to make this report as a matter of ordinary routine, and his duty appears to be simply to see that the charges made in the annual accounts are properly sanctioned by the Treasury and Parliament. He has nothing to do with their propriety or necessity: these are determined by the Treasury.

The head and front of all the complaints made against the Post-Office authorities is that expenditure has been incurred without the necessary constitutional authority. The most adverse critics have never suggested either wasteful or unnecessary expenditure. Many persons think that a high price was paid to the Telegraph Companies, but many other private companies, especially Gas Companies, have since been purchased by local authorities at much higher price. The Railway Companies have made outrageous and exorbitant claims, but in no case—so far as we can make out from a Return laid before Parliament—has a Railway Company succeeded in obtaining through arbitration more than the Post-Office was willing to give by agreement. Moreover, the claims made are being dealt with strictly in accordance with the Acts of Parliament, and before a tribunal above reproach or question. The public, we conceive, has received the fullest possible value for its outlay, in the shape of an improved, widely extended, and more stable telegraph service. The gravest offence committed by the Post-Office that we can trace is, that it has been too energetic in the service of its master—the public.

Telegraphic finance is divisible into two heads, viz., capital and current expenditure. The first was closed about a year and a half ago, on an undertaking of the late Prime Minister, and the second is necessarily incurred in maintaining and upholding the efficiency of the system. To carp at the first is to beg the question. The telegraphs have been purchased by the State, the public generally are very well satisfied with their bargain, the sums required for the purchase have been defined and supplied by Parliament, and no voice has yet been raised against the policy or advantage of that acquisition.

The fact that the annual nett receipts derivable from telegraphs do not at present suffice fully to pay the interest on the loans raised to acquire them, is no doubt a fair subject for comment and criticism. As a Journal interested in Telegraphy, we watch with anxiety for further information on this point. The natural growth of telegraphic business must shortly convert deficiency into surplus. Moreover, it is not fair to parade a deficiency of £100,000 a year without considering the equivalent which the nation receives. Besides the introduction of a cheap and uniform tariff, the telegraph has been carried to every considerable village in the three kingdoms, and that not merely to the railway-station or its outskirts, but to the very centres of population and business. A swift and reliable service has supplanted what was, in many cases, a slow and intermittent service. A costly and dilatory porterage has been replaced by a comparatively free and rapid delivery. A system of news despatch has been established on principles so liberal and perfect that the daily newspapers—even in the most distant provinces—are able, by its aid, to print reports, extending to many columns, of events occurring within a few hours of the time of publication. This could not have been possible

under any private system of commercial telegraphy, for the unification and re-arrangement of wires effected under the scheme of postal telegraphs have alone rendered it possible.

The Government has organised a telegraph administration that is a model for all countries to imitate, and it has succeeded in acquiring a revenue which at any rate exceeds working expenses; and the natural increase in the business itself, as well as the perfect manner in which that business is conducted, lead up to the confident expectation that the time is not far distant when financial equilibrium will be established.

THE VOLTAIC BATTERY.

A Course of Six Lectures,

By Dr. JOHN HALL GLADSTONE, F.R.S.,

Fullerian Professor of Chemistry, Royal Institution.

Delivered at the Royal Institution of Great Britain.—Christmas, 1874-5.

(Continued from p. 113.)

Lecture V.—Electrotyping, &c.

I want—in the remainder of the lecture to-day, and in the next lecture—to speak of the practical applications of the voltaic battery.

You are all aware, I dare say,—at least every girl and every boy ought to be aware,—that if you get hold of a truth it generally has some use, or outcome; if you get hold of a falsehood it is barren, it is useless or worse than useless to yourself and to those round about you. If you find a real fact it will abide by you, and you can turn it in one direction or another, and make it useful in various ways. It is the same with a true or a false theory. I spoke of that in the last lecture—did I not?—with regard to the theory of Galvani and the theory of Volta. Galvani's theory as to why his frog kicked was an incorrect one, and produced very little result. It would never have produced these beautiful things that we have upon the table here; but Volta had a better theory—a truer view. I do not say that it was perfectly true, but it was a nearer approach to the truth; and that theory became productive, and led people to think and work in various ways, and so we have these great results, and all these beautiful applications. Remember, then, that it is a great thing to get hold of a true fact or a true theory—great not only in itself, but also in the results that flow from it.

There were various early results from the galvanic battery. One thing that Davy tried was this:—You know that the bottoms of ships are coppered, in order to protect them from the water and from the things that are in the water. You know, too, perhaps, that the copper wears away gradually, and, of course, as copper is a costly thing, it was desirable, if possible, to protect the copper sheathing of the ships; and Davy thought that if he put various pieces of zinc about the copper, the zinc would dissolve and the copper would not. He tried it with what were called "zinc protectors," on the copper sheathing of the ships, and no doubt with very good effect, because the zinc did dissolve, and the copper was protected, in the salt water of the sea. That you can all understand, as you know something of electrical decomposition. But there was one disadvantage. He found that, as the copper did not dissolve, it became a famous place for all sorts of zoophytes, and algæ, barnacles, and protozoa to grow upon; and as the ship went through the sea it became a living forest of all these things belonging to the vegetable and animal world. This was very inconvenient, and retarded the ship, and so these protectors had to be taken away, when, of course, the copper—wearing away as before—was not covered so much with these living creatures of the sea. That was an application that brought an unsatisfactory result.

Another application was this—and I do not know why it ceased to be used. It may, indeed, be used still for anything I know. Some of you tried, I dare say, when you went home after the first lecture, an experiment with the zinc plate and copper held on the two sides of the tongue, and you found that there was an unpleasant flavour. Now the nurserymen took advantage of that property for use in gardens, and they thought that they could prevent soft animals climbing up their trees. I will draw a sketch of the arrangement:—Suppose we have a plant growing up. The plan was to put round the stem a little band of copper, and then a band of zinc. Then as the creature crawled along,—a snail, or slug, or caterpillar,—when the little fellow was on the copper, and put his head forward, he came upon the zinc; he did not like it, and at once threw his head back; but he tried it again, and still he did not like it: so at last, after various attempts, he turned tail, and went down the plant again.

The galvanic battery has been applied sometimes to machinery, and we have machines which can be worked by it. Here is one which I will set going with a little battery, consisting of two cells of Grove. There it goes. It depends upon the forming of temporary magnets. Magnets are made and unmade in rapid succession. Now the machine is going fast, and making even more noise than before. But there is a great deal more noise than work in this case: you will find that if we touch it in any way it will immediately stop. The difficulty is that we get very little mechanical work out of a galvanic battery. These machines are simply toys, and any attempts which have been made to apply the voltaic battery to large machinery have failed. The fact is that it is very much cheaper to burn coal in a steam-engine than to burn the coal in order to reduce the zinc which is dissolved in the battery. However, there is no mistake about the power being capable of production, and, of course, we can drive any sort of machine we please. Here is a little locomotive—a jolly little thing, which carries its own battery. It is a bichromate of potash battery. There are two carbon plates and zinc between, and the bichromate of potash solution is put in this cell. I have simply to lower the zinc, and there it goes. It takes itself along very well; but if we had a train of carriages attached to it I think it would be puzzled to go on. I dare say it would hardly run over my notes. Oh, yes, it will. I do not apprehend, however, for the reasons I mentioned to you just now, that we shall ever be going along our railways by means of galvanic batteries. Coal must be used in reducing zinc, and we can employ it better for making steam. How-

ever, there are many mechanical actions which do not require any strong power, and for those purposes it is useful. It has been applied to clocks, and by the kindness of Sir Charles Wheatstone we have an electric clock in the ante-room. Sometimes clocks have been made to work originally with electricity, but I do not think that these are so good as clocks which are merely regulated by electricity. We can attach a clock of this sort to other clocks, and thus we can employ common cheap clocks, and keep them timed by our standard clock by means of electricity. These clocks are employed for dropping time-balls and firing time-signals in different towns of England, and this is done very easily.

But another application of the galvanic battery, which is more common by far than its application to clocks, is the ringing of bells. Here I have a series of bells, and here is a Leclanché battery of two cells. I believe Mr. Murray told me that this battery has been going for a couple of years. The value of this particular kind of battery is that it only works when it is wanted, and it wears out very slowly. We have only to touch any of these knobs, and the battery sets something ringing. It has also brought out this mark —" Office." That shows that the bell is being rung from the office. We touch this other knob, and a bell is set ringing, and we bring out the word " Study," so that we see that the bell is being rung from the study. By merely pushing these knobs we make contact, and thus are able to ring the bell.

But a much more important application of the galvanic battery is to electrotyping, and to electro-plating and electro-gilding, and to that subject I invite your attention during the remainder of our hour.

You may recollect that I have already spoken to you about the simple electrotyping trough, and how we can copy medallions. This is such a trough as any of you can employ. It is sold in the shops at a cheap price. There are some still cheaper; but I have not brought a cheaper one here, though some of my own juveniles, with myself, tried one yesterday; for while we succeeded in making medallions we did not think they were quite good enough to present before you to-day. However, with this apparatus I have no doubt that we can easily prepare what we want. Here are the zinc and the medals, and there is the porous cell. Then we put the medals in a bath, and we pour into this bath any solution of copper. We put into the porous cell bisulphate of potash, or common salt if we please, and the zinc will dissolve in that. This is a copper wire, by which we can join to the piece of zinc any of these medallions we like, and then we have them hanging down at the side. A gradual change will take place, which is represented in the diagram, where you see the medallion hanging down. A change is taking place, and the copper is being deposited on the medallion, while the zinc plate—which is in the other cell—is being dissolved up at the same time. Any of you can try that if you like. We have some things which have been prepared in this way. Here, for instance, is a little medallion of Wellington. This has been just taken out, and there is the medallion with a rough outside; but there is no doubt about the perfection and smoothness of the impression itself. Probably it will be well just to pass round some of these for you to look at. But you understand that we never get any galvanic effect at all unless we have perfect conduction. The medals which are employed must conduct the force, and the liquid must conduct the force. Therefore, at first, it was supposed that it might be easy to copy a medal or a coin, but that it would not be possible to copy other things which are not conductors. But there was one great discovery made which brought about the copying of other things besides metallic bodies, and it is a discovery upon which, I think, an insufficient amount of attention has been bestowed. Without that discovery it would have been impossible for us to produce all these effects which we obtain now by the electrotype. Some discoverers have patented their inventions, and made large fortunes by them; but the gentleman who made this discovery —a friend of mine, long passed to his rest—did not think it worth while, or did not care to patent it. He, at first, merely announced it, I believe, at a Soirée in this Institution. It was Mr. Robert Murray—the father of Mr. Murray who lent me those bells and some other things in the room. This great discovery enables us to turn either a plaster of Paris cast, or a gutta-percha mould, or a wax mould, into a conducting surface. This great discovery was the application of black-lead to the surface of the cast or mould. You know black-lead, or plumbago, or graphite. It goes by those various names. Here are some fine specimens of that black-lead; but the black-lead which is employed in electrotyping is in a state of powder. Now black-lead is a very good conductor of electricity, and we have simply to rub these moulds over with it. Here is a gutta-percha mould which is somewhat elastic. Any of you can prepare the moulds like this, and there is no difficulty in getting black-lead at home and rubbing it over the moulds. You have then a conducting surface. Then you twist your wire round the mould, and if you like to varnish the back of the mould so much the better. Take care not to cover the back with black-lead. Place it in the bath, and in the course of an hour you will have the mould covered with copper where it has been covered with black-lead. If your first attempts are not successful, try again, and then you will be rewarded with success, and success which comes at last after a few failures is more valuable than success which comes in the first instance. When you have deposited all you want, lift off the copper with your thumb-nail, trim it with a pair of scissors, and then you can burnish it up and put a polish on it, or you can afterwards —by the process I shall describe to you presently—cover the medal with silver. You can turn it into a silver medal instead of a copper medal, or if you prefer gold to silver, as some people do, you can turn it into a gold medal.

Now that is the simplest kind of cell in which you can produce this electrotyping. In practice it is often actually carried on for commercial purposes in that way; but if you do not want the electrotyping on a large scale it is better to employ a separate battery. This is a small Smee's cell. You may take any other battery you like. It is better not to employ too strong a battery; but any of the forms will answer. The Smee and the Daniell are, however, perhaps the best for this purpose, because they act constantly, and comparatively slowly. You place across your trough a

band of metal, and then you can hang upon it any of your moulds by means of wires. You must do something else besides hang the moulds, because although you may put sulphate of copper in the bath, the sulphate of copper will grow weaker and weaker as the process goes on, and the supply must be kept up. The thing to do is to put a sheet of copper inside the liquid for the one pole, and then for the other pole, which is in connection with the zinc, you place your mould. Here we have a mould with a portrait of Rubens, and here a medal is formed. This has been going on since last night, and I see that it has got a very good coating of copper over it. At the end of the lecture we will open it and see how it looks.

But of course you may make a great many other things besides medals. For instance, if we want to take an engraving we can do it by this process. Here are some woodcuts I have had made. The figures have been cut into the wood. Here is a mould of wax which has been taken from the wood, after having been pressed by hydraulic pressure upon it. Then this wax mould was properly blackleaded, and it was put into a bath like this. I went over the works of Messrs. Knight and Hall, in which the thing was done, and saw the process. Of course the apparatus which we have here does the electrotyping only on a small scale; but at those works baths are employed as large as this table, and you may see, perhaps, a hundred things being coated at once. Large masses of copper are being dissolved at one end, while the metal is being deposited at the other. Here is one of the thin plates which were deposited upon the mould. You see it takes on one side perfectly the pattern of the mould, and on this side we have rough crystals of copper. Afterwards the impression is "backed up," as they term it, with other metals, and then it is employed for printing. The thing which was printed from this was the picture of the crystals which you have had put into your hands. I determined that this engraving should be electrotyped, in order that those papers should be examples of the art of electrotyping as well as representations of the crystals which I showed you on the screen. Of course it is possible not merely to deal with such things as these, but to electrotype printing type in the same way. If we set up common type we can take a wax mould from the type as in this case, and then we can get a copper deposit upon it. Here is a deposit sticking still to the mould. It is rough, you see, at the edges, and requires a little skill to remove it. Here is a deposit which has been removed. It has black-lead on one side, and bright copper on the other side. Then what is to be done is to back this up with a strong piece of metal and wood, and then after framing it and removing any imperfections, we can use it as a stereotype plate, and print from it to any extent we please.

Now this process is coming into use very largely indeed, both for the reproduction of engravings, and for the printing of magazines and books. But of course this power which we see reproducing engravings in this way may be employed for many other purposes. We can copy works of art; such, for instance, as some of these bronze figures which we have here. Here is a bust of my old teacher, Liebig—a good likeness of him. It has been kindly lent to me by Dr. Hugo Müller. It is a thick copper bust which has been produced by the electrotype. Here is an electrotype reproduction of an antique bronze of Hercules and the stag. Hercules is not there, but the stag is. This other figure is Caractacus. These have been done by Messrs. Elkington. I hold in my hand a copper bar. You see what soft copper we can produce by voltaic deposition. It can be bent round and twisted, and we can cut it easily; or we may have the same metal in a brittle and crystalline form. Here is a plaster of Paris mould instead of the gutta-percha or wax moulds which I showed you, and there are some things which we reproduced from the plaster. This thick rail of copper is one of the cylinders used in calico printing, and it is engraved by means of this art. The process is very much the same as I have already described to you. Or, if we like, we can take a smooth copper roller of this sort and put varnish upon it in the form of a pattern, and corrode away the parts not varnished.

This art has also been employed for copying many things in nature as well as in art. For instance, this is a reproduction of a piece of leather—pigskin, in fact. Anyone who looks into this will see that it is not any human imitation, but there is the real moulding of nature, and there is no mistake about it. Here is an electrotype taken from a frog, and we have got here all the different markings of the batrachian's skin very perfectly. Messrs. Elkington have sent me this beautiful photograph of a basket filled with natural ferns, coated with gold, silver, and copper, which was presented by them to the Princess of Wales. We can take ferns and cover them over with a delicate coating of copper and preserve them in that way, and very pretty they look.

But I must speak of other things. We can deposit not merely copper and bronze, but other metals too. Mr. Walenn has kindly furnished me with some specimens of what promises to be a very interesting application. This is copper deposited upon iron. This was the first piece of the kind he ever produced. It is a little iron basin with the copper deposited upon it. He places a piece of copper in the bath, and he uses cyanide of potassium and tartrate of potash, and the copper gradually dissolves in those salts, and is deposited slowly and toughly on the iron. Here are some specimens which exhibit this deposit on the iron. In order to show how closely it sticks to the iron I may say that you can scarcely separate the one from the other. You can get a very thick deposit of copper, not at all of a brittle or crystalline character; and you can see that the copper is about as tough and uncrystalline as any piece of copper which you see anywhere. Of course it can be hammered as any other piece of iron, or copper, or brass. You can dissolve brass in your bath in the same way; in fact, it is almost impossible to say what metals you may not deposit in this manner. Mr. De la Rue has sent me this very delicate specimen. It is a representation of the corona during the eclipse of the sun. In order to render that plate more durable it has been covered with an exceedingly thin film of iron, and this has been removed in one part so that you can see the copper beneath. You can see, too, how exceedingly thin the film of iron is. But that thin film of iron gives additional strength and sharpness to the engraving.

Then we can take other metals, for instance silver, and deposit them. If we want to treat silver in this way, we must take a solution of cyanide of silver and potassium—argento-cyanide of potassium, which can be prepared by the battery or otherwise. And then we have to work with that much in the same way as we worked with the sulphate of copper, employing a battery or a machine like this (Gramme's). In the large works of Messrs. Elkington, the patentees of this art, or of others who practise it, they suspend a piece of silver in the bath and make that one electrode, and at the other end they suspend their teapots, or spoons, or anything else they wish to cover with silver. These articles are made of nickel alloy, what is called German silver; but you may take almost any metal you please; though some metals require a different manipulation. If we take nickel —this white metal, or German silver—the pure silver is deposited very easily, and more strongly on the prominent parts, and less strongly in the interior parts. I ought to say that great care must be taken, when you are working in this way, to have your moulds perfectly clean. In electro-plating, I believe, it is exceedingly important that everything should be perfectly clean, and that you should cover over your metallic mould first of all with a little layer of mercury, by dipping it for an instant into nitrate of mercury, and then the mould with the mercury upon it is capable of taking the silver very easily. The silver attaches firmly to it, and by proper management it may be deposited either in a bright condition or in a dull condition, as we wish, and more or less quickly. All this depends upon the art of the manufacturer. Of course you may find out many ways in which you can modify your results. The articles may afterwards be burnished, and you may produce any polish you like upon the plating. Supposing you want to plate with gold, you must take auro-cyanide of potassium instead of argento-cyanide of potassium. The process is substantially the same. The only real difference is that you have to employ warm solutions in order to get a good effect with gold. Silver is deposited in cold baths—gold in warm baths. I ought to state that if you want to cover an article with gold, it is first covered with silver, and then the gold is deposited on the silver. If you wish to produce such things as we have upon the table, which are partly silver and partly gold, you cover the whole of the article with silver, and then you protect with varnish those parts upon which no gold is to be deposited. The article is then put into the bath of gold, and the gold is deposited upon the unprotected portions, while upon the varnished portions nothing is deposited. Here we have gold and silver figures of horses which have been covered over with this dark-coloured varnish, which has been allowed to remain upon them. By such means as these we are able to produce various effects—such effects as are exhibited in the beautiful specimens which are arranged upon the table. I am indebted to Messrs. De la Rue for a great number of these specimens of electrotyping, and to Mr. Walenn, and others. And I ought to mention especially my indebtedness to Messrs. Elkington and Company for these bronze statues, and for the fine display of beautiful works of art in electro-plate and electro-gilding which are now exhibited on the table in front.

THE ROYAL INSTITUTION.

Notes of a Course of Seven Lectures on Electricity.
BY PROFESSOR TYNDALL, LL.D., F.R.S.

February—March, 1875.

(Continued from page 126.)

NOTES OF LECTURE VI. *March* 11, 1875.

1. Lichtenberg devised a means of revealing the condition of an electrified surface by dusting it with powder. Red-lead, in passing through muslin, is positively electrified; flower of sulphur is negatively electrified. Whisking a fox's brush over a cake of resin, and drawing over the surface the knob of a Leyden jar, positively charged, the resin is rendered in part negative and in part positive. Dusting the mixed powder over the surface, the sulphur arranges itself over the positive places, and the red-lead over the negative places, a very beautiful figure being the result. The figures produced by the positive electricity are quite distinct in form from those produced by the negative.

2. This experiment of Lichtenberg's constituted the germ of Chladni's important acoustical researches "Chladni's figures" were the direct offspring of "Lichtenberg's figures."

3. Cadogan Morgan, in 1785, sought to produce the electric spark in the interior of solid bodies. He inserted two wires into wood, and caused the spark to pass between them: the wood was illuminated with blood-red light, or with yellow light, according as the depth at which the spark was produced was greater or less. The spark produced within an ivory ball, an orange, an apple, or under the thumb, illuminates these bodies throughout. A lemon is especially suited to this experiment, flashing forth at every spark as a speroid of brilliant golden light. A row of eggs is also brilliantly illuminated throughout at the passage of every spark from a Leyden jar.

4. At an early period efforts were made to determine the direction in which the electricity moved. When a card, or a pack of cards, was perforated by the electric spark a burr was formed both at its place of entrance and its place of exit from the card. This indicated the operation of a power acting in two directions rather than in one direction.

5. We have already illustrated Franklin's cascade battery, in which the outer coating of each jar is connected with the inner coating of the next following jar. In the ordinary battery all the inner coatings are connected together, and all the outer coatings are connected together. Such a battery acts as a single large jar of extraordinary dimensions.

6. Wires are warmed by a moderate electric discharge, by augmenting the charge they are caused to glow. The heat developed is proportional to the square of the quantity of electricity (measured by the unit-jar). With strengthened charge the metal is torn to pieces; fusion follows; and by still stronger charges the wires are reduced to metallic dust and vapour.

7. For such experiments the wire must be thin. Without resistance we can have no heat, and when the wire is thick we have little resistance. The mechanism of the discharge, as shown by the figures produced, is different in different wires.

The figure produced by the dust of a deflagrated silver wire on white paper is especially beautiful.

8. When the discharge of a powerful battery is sent through a steel chain several feet in length, the lateral scattering of the particles of the chain and their combustion in the air constitute a brilliant and instructive experiment. Chain cables have been fused by being made the channels of a flash of lightning.

9. Retaining our conception of an electric fluid, at this point we naturally add to it the conception of *a current*. It is the electric current which produces the effects just described. In many of our former experiments we had electricity at rest (static electricity); here we have electricity in motion (dynamic electricity).

10. Sending the current from a battery through a flat spiral (the primary) of copper wire, and placing within a little distance of it a second similar spiral (the secondary) with its ends connected, the passage of the current in the first spiral excites a current in the second, which is competent to deflagrate wires, and to produce all the other effects of the electrical discharge. Even when the spirals are some feet asunder, the shock produced by the secondary current is still manifest.

11. The current from the secondary spiral may be carried round a third; and this third spiral may be allowed to act apon a fourth, exactly as the primary did upon the secondary. A tertiary current is thus evoked by the secondary in the fourth spiral.

12. Carrying this tertiary current round a fifth spiral, and causing it to act inductively upon a sixth, we obtain in the latter a current of the fourth order. In this way we generate a long progeny of currents, all of them having the current first sent from the battery for a common progenitor. To Prof. Henry, of the United States, and to Prof. Riess, of Berlin, we are indebted for the investigation of the laws of these currents. These researches, however, were subsequent to—and were indeed suggested by—experiments of a similar character previously made by Faraday with voltaic electricity.

13. Franklin made an exhaustive comparison of the effects of electricity and those of lightning. The lightning flash is of the same shape as the elongated electric spark; like electricity, lightning strikes pointed objects in preference to others; lightning pursues the path of least resistance,—it burns, dissolves metals, rends bodies asunder, and strikes men blind. Franklin imitated all these effects, striking a pigeon blind, and killing a hen and turkey by the electrical discharge.

14. Having completely satisfied his mind by this comparison of the identity of both agents, he proposed to draw electricity from the clouds by a pointed rod erected on a high tower. But before the tower could be built he succeeded in his object by means of a kite with a pointed wire attached to it. The electricity descended by the hempen string to a key at the end, the key being separated from the observer by a silken string held in the hand: he thus obtained sparks, and charged a Leyden phial with atmospheric electricity.

15. But, spurred by Franklin's researches, the electrical character of lightning had been previously proved in France. A translation of his letter fell into the hands of the naturalist Buffon, who requested his friend D'Alibard to revise the translation. D'Alibard was thus induced to erect an iron rod 40 feet long, supported by silk strings, and ending in a sentry-box. It was watched by an old dragoon named Coiffier, who, on the 10th of May, 1752, heard a clap of thunder, and immediately afterwards drew sparks from the end of the iron rod.

16. The danger of experiments with metal rods was soon illustrated. Richmann, of St. Petersburg, had a rod raised 3 or 4 feet above the tiles of his house. It was connected by a chain with another rod in his room; the latter resting in a glass vessel, and being therefore insulated from the earth. On the 6th of August, 1753, a thunder-cloud discharged itself against the external rod; the electricity passed downwards along the chain: on reaching the rod below it darted from it to Richmann's head, which was about a foot distant, and killed him on the spot. Had a perfect communication existed between the lower rod and the earth, the lightning in this case would have expended itself harmlessly.

17. In 1749 Franklin proposed lightning conductors. He repeated his recommendation in 1753. He was opposed on two grounds. The Abbé Nollet and those who thought with him considered it as impious to ward off heaven's lightnings as for a child to ward off the chastening rod of its father. Others thought that the conductors would "invite" the lightning to break upon them. A long discussion was also carried on as to whether the conductors should be blunt or pointed. Wilson supported the first view, against Franklin, Cavendish, and Watson. He so influenced George III. that the pointed conductors on Buckingham House were changed for others ending in balls. Experience of the most varied kind has justified the employment of pointed conductors. In 1769 St. Paul's Cathedral was first protected.

18. The most decisive evidence in favour of conductors was obtained from ships; and it was required, to overcome the obstinate prejudice of seamen. Case after case occurred in which ships unprotected by conductors were singled out from protected ships, and shattered or destroyed by lightning. The conductors were at first movable, being hoisted on the approach of a thunderstorm; but these were finally abandoned for the fixed lightning conductors devised by the late Sir Snow Harris. The saving of property and of life by this obvious outgrowth of electrical research is incalculable.

Experiments in Lecture VI.

(1.) Note 1 was illustrated with the cake of an electrophorus. The negative sulphur formed branching and stellar shapes of great beauty on the positively electrified portions of the cake.

(2.) To connect them with Lichtenberg's figures an example of Chladni's figures was shown. Fine sand being strewn upon a brass plate a foot square, the plate was caused to emit a musical sound; the sand immediately retreated from the vibrating portions of the plate and arranged itself sharply as a system of "nodal lines," along the places of no vibration.

(3.) Two thick wires were pushed into an apple from opposite points, and brought within about ½ an inch of each other within the apple. On causing the spark of a Leyden jar to leap over this interval

the apple glowed. The glow of a lemon under the same circumstances was particularly brilliant. A row of eggs in a tall glass jar, with its metal bottom connected with the earth, shone brightly when the discharge passed through them.

(4.) The arrangement, charging, and discharging of the ordinary electric battery were illustrated, as also the use of the unit-jar.

(5.) Seven cards were placed between the knobs of the universal discharger. After the discharge had passed through them, the central card was found without any burr. Right and left from this the burr was in opposite directions, being most pronounced in the case of the two external cards.

(6.) Wires of platinum and of silver were deflagrated, leaving the impress of the metallic dust on white paper.

(7.) The lateral scattering of the metal was further illustrated by sending the charge through a steel chain. The chain, during a passage of the electricity, bristled with lateral spikes of light.

(8.) Note 10 was illustrated by deflagrating 6 inches of silver wire by the secondary discharge. When the spirals were far apart, gun-cotton—placed between the knobs of the universal discharger—was ignited by the secondary spark.

ON TELEGRAPH CONSTRUCTION.

By JOHN GAVEY, Assoc. Soc. Tel. Engineers.

In this and the following papers, we propose, in considering the general principles to be adopted in laying out and constructing telegraph lines, endeavouring to deal with the subject in a sufficiently elementary manner, to enable those members of the telegraph staff who have little or no outdoor experience to lay the foundation of that knowledge which they may be called upon to apply practically at a later period.

1. *Selection of Route.*

The first point for consideration in dealing with the question of connecting two distant places by means of a line of telegraph is the route to be adopted. In highly civilised and thickly populated countries this question is easily settled, for well-constructed maps, giving clearly and distinctly all the physical and artificial details of the country, are readily obtainable. In England, the excellent maps, on the scale of one inch to the mile, published by the "Ordnance Survey," serve most of the practical purposes required for telegraph engineering; whilst if more minute details are needed, reference can be made to the maps on the scale of 6 inches and 25 inches to the mile, which are issued for many districts.

In very thinly populated, uncivilised, or uninhabited countries, this resource is not always to be had, and special surveys may have to be made, and rough plans of the country prepared specially, before a route is decided upon.

Assuming, then, that the maps of the localities about to be served have been obtained, a brief examination will put the engineer in possession of the various routes which lie before him, and these may be considered under the heads of ordinary roads, railroads, canals, and open country.

It will very frequently happen that the engineer will have a choice of at least two and sometimes of three of these classes of routes to select from. In such cases, however, the choice will not generally be decided by a balance of engineering advantages or disadvantages, but by expediency, or by commercial questions apart from engineering considerations. We do not therefore propose to re-discuss the vexed questions of road versus railway and canal telegraphs, but simply to describe the method of procedure in each case.

High Roads.—Having traced out the main roads connecting the two localities, obtained the approximate mileages, noted the towns and villages lying in either route, and collected such information concerning each as is generally furnished by office records, the next step is to make a preliminary inspection of the whole of them, to decide on the best line of road to be adopted. This inspection is readily made on horseback or by driving, as a sufficient knowledge of the country will be obtained in this manner to enable an officer with moderate experience to draw up a balance of advantages in favour of the best route, and much less time will be absorbed than if walking be resorted to.

Ample notes should be taken by the way of all prominent features of the country, and of all matters likely to affect the construction or subsequent maintenance of the line. Amongst the most prominent points which demand attention are the width of the roads in various localities, and the amount of waste ground, if any, on either side, jottings as to the description of soil, the banks, ditches, and trees lining the road, together with notes as to parks, mansions, family residences, &c., if these are likely to affect the construction of the line.

Indications as to the best side of the road to adopt, and the points where it should be crossed in various lengths, will materially assist the surveyor in his subsequent work. Brief notes as to the best means of passing the towns and villages on the way, may likewise be of service, and where there is reason to anticipate exceptional difficulty, or costly work, this fact should have due attention.

During the progress of the inspection, full particulars, including the names of the officers of all controlling bodies of each length of road, should be obtained; the periods and localities at which the meetings are held; and any other details likely to assist in obtaining the necessary consents for proceeding with the work. The names of large landowners also should be recorded, although time need not be lost in ascertaining the latter particulars.

This information should be embodied in the form of a schedule, giving the name and approximate length of each parish, trust, or municipal borough, together with the other details referred to. This preliminary inspection complete, the materials are furnished for forming a definite judgment as to the best route, and, commercial and traffic considerations aside, the choice should be given to that which possesses most of the following advantages:—

(1). The fewest curves, or the most gentle ones.
(2). The least encumbered with trees, without, however, being too much exposed.
(3). The fewest villages (which are occasionally very troublesome), parks, or ornamental grounds.

(4). The widest, with the largest amount of waste by the side.
(5). Other things being equal, the most sheltered from prevailing winds.
(6). A road in too close proximity to the sea, or to collieries, blast furnaces, and metal or chemical works, should be avoided when practicable.
(7). Crossing arms of the sea or navigable rivers by means of cables, is frequently a source of after trouble. It is worth adding somewhat to the length of the line to avoid this. When most, or all, of the advantages detailed can be obtained, the minimum difficulty is found in executing the work, but even when the majority of them are absent, and we cannot generally expect many for any long length, it is simply a question for the skill of the engineer to overcome the additional difficulties.

The route having been decided upon, formal application is made to the bodies controlling the roads, and their consents being obtained, the actual survey may be proceeded with.

Railways.—The preliminary investigations on a railway need be but brief. There is not, like in the case of high roads, a choice of lines, with a balance of advantages and disadvantages to decide upon. The only questions involving special consideration before the survey commences, are those connected with station buildings, large station yards, tunnels, viaducts, and steep perpendicular cuttings. These are questions which of course affect the estimated cost of the work, and for this primarily, and also to enable instructions to be given as to the method of dealing with each of these special points, is the preliminary inspection needed.

Canals.—The remarks made as to railways apply to a considerable extent to canals. Natural difficulties arising from sharp curves, confined space, numerous bridges, aqueducts, abrupt variations in level, and other points involving departure from the ordinary route, or special expenditure, have to be noted and provided for, together with, it may be, intervening stretches over roads or private property.

Lines through Open Country.—The cases in which it is necessary to erect lines through the open country for any considerable distance in highly civilised districts, are few. Even where considerable spaces of waste or uncultivated land exist, they are generally traversed by roads; and it is advisable to follow these as closely as convenient, on account of the facilities for transport, inspection, and maintenance thereby afforded. Where it becomes necessary, however, to depart widely from known roads, the natural features of the country must be observed, and the line offering the shortest route and the fewest difficulties in the shape of hills, streams, &c., together with that affording the best transport and the most shelter, must be adopted. The immediate cost of erection is not the only point to be borne in mind, but the future maintenance of the line is a question of the highest importance. It will thus be seen that unfrequented localities difficult of access, should be, where possible, shunned as increasing the difficulties in the speedy removal of faults when such arise.

2. *Survey and Consents.*

The route having been decided upon, and the necessary consents having been obtained from the controlling bodies, the question of survey next arises.

Instruments used in surveying.

The Chain, commonly called "Gunter's chain," is that most generally used in England, for measuring distances required in a survey. It is 22 yards or 66 feet long, and is divided into 100 links joined by rings. At every tenth link pieces of brass of different forms are fixed, affording ready means of counting the links. "Gunter's chain" is especially useful for measuring areas, as it forms a decimal of an acre, this being equal to ten square chains, or 100,000 square links. It is, perhaps, scarcely so well adapted for mere ordinary linear measurements, when speed, as well as exactitude, is required, especially as in telegraph surveying, where numerous short lengths have to be measured; as each link being equal to 7·92 inches, an awkward fraction is introduced in every case.

A chain of 22 yards, or in some cases of 100 feet, with links 1 foot long, is better adapted to such purposes. The chain becomes extended by constant use, and it requires occasional verification and correction by the removal of intermediate rings.

Accompanying the chain are ten arrows, which simply consist of pieces of No. 4 wire, pointed at one end, and provided with a loop at the other for convenience of handling.

Two men are needed for chain measuring, one at each extremity. The first man or leader starting with the ten arrows in his hand, walks in the direction to be measured, the follower remaining at the starting point. When the chain is fairly extended in the required direction, the leader inserts an arrow in the ground at the extremity of the chain. Both men then move forward together till the follower arrives at the first arrow. The leader then deposits a second one, the follower takes up the first, and both move on. This is repeated till all the ten arrows have been collected by the follower. The latter will then have measured ten chains. The arrows are returned to the leader, and the same operation recommences. When lesser distances than ten chains have to be measured, the arrows should be exchanged for each measurement.

The measuring tape consists of a painted tape enclosed in a cylindrical leather case. It measures 22 yards in length, is divided into feet and inches, and is wound on a small cylinder inside the case. The best tapes are technically termed "wire tapes," because a few threads of fine brass or copper wire are woven into the substance and run through its entire length. This to a great extent prevents extension and tearing, and such tapes are more exact and more durable than common ones.

Offset Staff.—These are designed primarily to measure short distances or offsets, but they serve the equally important duty of ranging staffs for plotting out the positions of the poles, running straight lines along the ground, judging the value of angles, &c.

They are usually 6 feet long, painted black and white, in 6-inch lengths, and if provided with clamps at each extremity, to admit of two or three being fitted together, they are found very service-

able for obtaining a route or direction, when intervening obstacles obscure the direct line of vision.

Notes.

It appears from the Report of the Controller and Auditor-General on the capital account of the Post Office Telegraphs, that the total cost of the Postal Telegraph system up to the close of the financial year 1872-3, was £9,085,458.

The Derby result this year numbered over 1400 messages. During the four days of the meeting, some 13,500 messages were dealt with at the Epsom Post Office and the Telegraph Office at the Grand Stand, of which 1650 were for the Press. On the Derby day the total number of messages approximated 4500, being an increase of 300 on the number for the corresponding day the preceding year. On the Oaks day the number was 3200, being an increase of nearly 500. In 1870, the first year after the Post Office acquired the telegraphs, the Derby day produced barely 1600 messages, whilst the total number for the week was hardly in excess of that dealt with on the Derby day of the present year.

The following is from the Cuba Submarine Telegraph Company (Limited):—Information has been received of the interruption of the cable between Punta Rassa and Key West, connecting the West India Islands and Panama with North America. Telegrams are being conveyed by steamer, at an average delay of about one day.

In concluding his lectures "On Chemical Force," at the Royal Institution, Professor Gladstone, F.R.S., described a series of experiments recently made by himself and Mr. Tribe by means of what is called the copper-zinc couple. When thin sheets of zinc are immersed in a solution of cupric sulphate, copper is deposited upon it in a minute state of division, and thus the two metals touch at myriads of points. When this couple is immersed in a binary liquid, the liquid at each point of junction is exposed to the full chemical or electromotive force of the metals. It was shown that this obviates the great difficulty there often is in decomposing a liquid on account of the "resistance" which it offers, and the lecturer exhibited the breaking up in this way of pure water, iodide of ethyl, chloroform, and many other substances with the production of pure hydrogen, zinc ethyl, hydrides, &c., and several bodies previously unknown, some of which are spontaneously inflammable in the air; in fact, one substance which had never been made before was prepared expressly for the lecture, and was named zinc ethylo-chloride. The copper-zinc couple has been practically applied to the production of certain organic compounds, and to the determination of nitrates in potable waters.

The fourth International Telegraph Conference was opened at St. Petersburg on the 1st June by General Timaschew, Minister of the Interior, who delivered an address to the members, concluding with an assurance that the pacific feelings expressed by the Emperor are the unanimous aspirations of the Russian nation. Signor d'Amico, the Italian delegate, replied on behalf of his colleagues.

We are informed by the Great Northern Telegraph Company that, according to information received from Foochow, an agreement was entered into and signed there on the 21st May, between the Chinese Government, represented by the Imperial Commissioner Shen Panchen, Viceroy and General in the Province of Fookien, charged with full powers by Tsung-li-Yamen, Minister for Foreign Affairs in Pekin, and the Great Northern Telegraph Company, to the following effect:—The Chinese Government pays the Company full compensation for the damage done to the Foochow-Amoy line in January last. The Company to erect a line of telegraphs between Foochow and Amoy for account and use of the Chinese Government. Inland telegraph stations to be established in Amoy, Foochow, and the two intermediate towns, Hinghua and Chuenchan. The working of the line to be undertaken by the Company for account of the Chinese Government.

At a recent Board meeting of the Anglo-American Telegraph Company, it was resolved that on and after the 2nd of June the estimated gross receipts of the Company for the previous day be posted daily at the offices.

Although the traffic returns now exhibited by the Anglo-American Telegraph Company show a falling off compared with the corresponding period when the 4s. tariff was in force, the cheaper rate is beginning to tell in the increase of messages. The daily average earnings last month were £1095 against £1813 in May, 1874, when the charge was 4s. per word, so that the reduction of 50 per cent in the tariff only involved a loss of 38 per cent in the receipts. On Wednesday last the receipts were £1400 against £1240 on the previous day, while the daily average in that month last year was £1959. The decrease was thus only 28 per cent, the diminution in charge being 50 per cent. On Thursday the receipts were £1340, and on Friday £1350.

At a meeting on Monday, June 7, at the City Terminus Hotel, of the Eastern Extension, Australian, and China Telegraph Company, the following Resolutions were passed :—" 1. That the report of the Directors recommending the extension of the telegraphic system of the Company to New Zealand be and is hereby adopted, and that the Directors be and are hereby authorised to proceed with such extension, and to enter into all necessary contracts, and to do all necessary acts, to effect such extension. 2. That the Directors be and are hereby authorised to enter into such agreement or agreements, or make such other arrangements as they shall think fit, on behalf of the Company, with the Hon. Sir Julius Vogel, on behalf of the Government of New Zealand, for defining and settling the terms and conditions of telegraphic communication by the Company with that Colony."

The traffic receipts of the Eastern Telegraph Company for the month of May amounted to £30,602, against £30,225 at the corresponding period of 1874; and of the Eastern Extension, Australasia, and China Telegraph Company, to £17,773, against £18,879 last year.

The traffic receipts of the Brazilian Submarine Telegraph Company (Limited) for the month of May amounted to £12,080.

The number of messages passing over the Cuba Submarine Telegraph Company's lines during the month of May (including those received at the new station at Cienfuegos) was 2481, estimated to produce £2400, against 1788 messages, producing £1851, in the corresponding month of last year. The actual receipts for the three months ending March amount to £7153 as compared with the estimated amount of £7100.

The Direct United States Cable Company announces the completion of through communication with America by means of their cable. Further particulars will shortly be given.

The traffic receipts of the Direct Spanish Telegraph Company (Limited) for the month of May, amounted to £1442 9s. 2d., against £1494 14s. 6d. in April.

The Secretary of the Direct Spanish Telegraph Company (Limited) informs us that the average time occupied in the transmission of telegrams between Madrid and England, *via* Santander, during May, was three hours and twenty-six minutes (including transmission over Spanish land-lines).

The traffic receipts of the Great Northern Telegraph Company for the month of May were—this year, 366,423 francs; last year, 363,932 francs. Total traffic receipts, 1st January to 31st May—this year, 1,602,397, francs; last year, 1,689.998 francs.

UPON THE

INDUCED CURRENTS PRODUCED BY THE APPLICATION OF ARMATURES TO HORSE-SHOE MAGNETS,

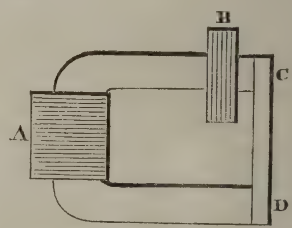
AND A

NEW FORM OF MAGNETO-ELECTRIC ENGINE.

By W. R. MORSE.

The apparatus consisted of cylindrical horse-shoe electro-magnets, the wires of which were wound about the iron cores at the bend of the iron, so as to form practically straight electro-magnets with cores, horse-shoe in form. Upon one of the limbs of the horse-shoe core a coil of fine wire was slipped so that the plane of its coils was at right angles to those of the electro-magnet. In Fig. 1 A represents the coil of

Fig. 1.



the electro-magnet; B, that of the induction coil. Upon exciting the electro-magnet induction currents arose in the coil of fine wire B both at making and breaking the circuit. These currents were measured by a reflecting galvanometer placed in the circuit of the coil B, and were compared with those obtained from the same electro-magnet by placing a straight armature C D upon its poles and then exciting the electro-magnet. The following table shows the results obtained. Only the currents resulting from making the circuit are recorded, those proceeding from the breaking of the circuit being the same in value. The readings are expressed in the divisions of the scale of the reflecting galvanometer :—

Without Armature.	With Armature.	After Removal of the Armature. 1st Deflection.	After Removal of the Armature. 2nd Deflection.
170	210	210	170
170	209	209	170
175	209	209	170
170	210	210	175

These results show that a marked increase (in these experiments nearly 25 per cent) in the strength of the induction currents results from the application of an armature to the poles of the electro-magnet. The third and fourth columns of the table show that after the removal of the armature, the first induced current which results from again making the current in the electro-magnet, shows the same increased effect; but that the following current resulting from breaking the circuit of the electro-magnet falls to its normal amount. This result is noteworthy, for it shows a certain molecular change in the iron which results from the application of the armature.

Although we can thus increase the strength of the induction currents produced in coils slipped upon the limbs of an electro-magnet, we diminish the lifting power of these individual limits by the employment of an armature, as the following results show :—

Weight Lifted without Armature.	Weight Lifted with Armature on.
249	160
300	180

In the preceding experiments the straight iron bars forming the armatures were carefully deprived of whatever residual magnetism they might possess.

Experiments were next tried upon the effect of horse-shoe electro-magnets used as armatures to electro-magnets of the same character as those employed in the preceding experiments. When two north or two south poles were opposed to each other, and the magnetic circuit, so to speak, of the two horse-shoe-shaped cores was closed, very feeble indications were shown by the galvanometer. When, however, a north and a south pole were opposed, and the magnetic circuit closed, the strength of the currents obtained both on the application and the removal of the armature were very marked, as the following results show:—

At Contact of N. and S. Poles.	On Removal of N. and S. Poles.
+360	−359
+362	−360
+361	−361

When the horse-shoe magnet forming the armature was not used, and one of the limbs of the stationary electro-magnet was quickly slipped in and out of the induction coil, induction currents were obtained, the values of which are shown below—

Placed in.	Withdrawn.
+40	−40
+40	−40
+40	−40

In these experiments the stationary electro-magnet and the electro-magnetic armature were of the same size and the same magnetic strength.

Experiments were next made upon the influence of the mass of iron forming the armature. This was found not to have so much influence as the residual magnetism of the iron. The results were very contradictory, as the following table shows:—

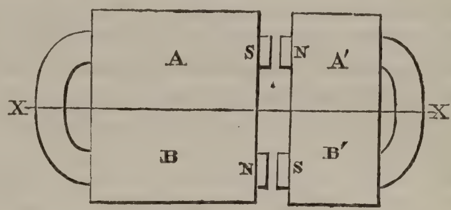
Weight of Armature. Grms.	Deflection Produced.
364	280
341	330
222	290
137	280
132	290
67	310

We are led to believe that the mass of the iron does not affect the results when it exceeds that of the stationary electro-magnet.

The induction currents resulting even from the employment of straight soft iron armatures which had been carefully deprived of residual magnetism, are thus seen to be more than four times as strong as those obtained by merely slipping the induction coil on and off the limits of the electro-magnet; which is, practically, the method adopted in many later forms of the magneto-electric engine, particularly in that of the Gramme machine, in which different portions of a ring-shaped electro-magnet revolve toward and away from the poles of a horse-shoe magnet. When electro-magnetic armatures are used, the effects far surpass those obtained by non-magnetic soft iron straight armatures, as the preceding results show.

Professor Trowbridge suggests a magneto-electric engine of the following construction:—The horse-shoe armature is made to revolve about the line X X as an axis. By the preceding experiments it has been found that when a north and a south pole are opposed, the induction currents flowing through B and A′ are in the same direction, and those through B′ and A are also in one direction. By a suitable commutator the currents circulating through the coils on the stationary magnet can be sent through those on the armatures, and *vice versa*. The residual magnetism in soft iron is sufficient to start the induced currents. Instead

Fig. 2.



of one stationary electro-magnet, it would probably be better to employ a number arranged about the axis X X. With projecting pieces of soft iron arranged upon the poles of the stationary magnets, the size of the horse-shoe armature could be regulated to suit the varying conditions of speed.

Experiments are now being made on this form of engine.—*Amer. Journ. of Sci. and Arts.*

Proceedings of Societies.

SOCIETY OF TELEGRAPH ENGINEERS.

The last ordinary general meeting of the session was held on Wednesday, the 12th May, Mr. Latimer Clark, President, in the chair.

The first paper read was on "*Battery Measurement*," by Mr. Frederick Hawkins, who explained a rapid and easy method of taking all the various measurements of the resistance and electro-motive forces of batteries with the same galvanometer. The *modus operandi* was explained after the meeting was over, and shown by a galvanometer in action. Mr. Hawkins has secured a larger range of deflection of the reflecting galvanometer than usual.

Colonel Stothard, R.E., subsequently read a paper on "*Earth Connections of Lightning Conductors.*" It appeared that in the year 1855 a small powder magazine close to the sea coast at East London, Cape of Good Hope, was struck by lightning; the solid iron conductor was torn to pieces, and the building much damaged, but none being done to the powder. A subsequent examination showed that the iron rod forming the conductor was split up, and portions of it broken off. The conductor terminated in a dry water tank resting on soil of 12 inches of sand overlying old red sandstone. Two points in connection with the case were raised. 1. The use of tanks as a means of connecting lightning conductors with the earth. 2. The employment of iron for conductors instead of copper.

With regard to the first point, it was subsequently announced that the War Office had abandoned the termination of lightning conductors in such places as tanks. In the discussion which ensued some diversity of opinion was expressed relative to the superiority of iron over copper. It, however, came to the point that the cost as to equal conductivity was about equal, whilst the question of durability was most decidedly in favour of copper.

Mr. Preece related the extraordinary circumstances under which Mr. Pidgeon, his wife, and son, had been struck by lightning in his garden at Paignton, Torbay (an account of which appeared in *Nature*), and detailed the case; the flagstaff near which they were was broken in pieces, and various damage done. The

course of the lightning, with its bifurcations, was illustrated by diagrams, and Mr. Pidgeon himself brought further evidence to bear upon the point.

Dr. Mann, the President of the Meteorological Society, spoke at some length, and much interested the Society by his lucid explanations. The discussion was joined in by many members, but it may be remarked that, like many other cases cited, the Paignton case was due to a bad earth. The ground being rocky, and, so to speak, partly insulated, the lightning spread out in broad surface. The "Insulated Island," as St. Pierre is telegraphically known, was cited. The discussion was closed at a late hour with an announcement from the President that the meetings of the Society would be resumed in November.

Notices of Books.

The Year Book of Facts in Science and Arts for 1874. Edited by C. W. Vincent, F.C.S., &c. London: Ward, Lock, and Tyler.

This is a fresh issue in a new cover of a very old and well-known annual. Mr. Timbs, its originator, has unfortunately departed, but his mantle has descended upon Mr. Vincent, who has rehabilitated and thrown fresh vigour and force into a very valuable book. There were indications in the recent volumes that Mr. Timbs's sources of information were narrow and few, but Mr. Vincent has gone wider and further afield, and the value of the book is enhanced accordingly. It is a very useful work of reference.

Post-Office Telegraphs.—Statement showing the total number of messages forwarded from Postal Telegraph Stations in the United Kingdom during the week ended the 29th May, 1875, and during the corresponding week of 1874:—1875, 409,008; 1874, 346,635; increase in the week of 1875 on that of 1874, 62,373.—Week ended 5th June, 1875, and corresponding week of 1874:—1875, 415,296; 1874, 385,279; increase in the week of 1875 on that of 1874, 30,017.

Telegraph Paper.—The earliest forms of telegraph instruments possessed a certain economy over those now in use. They were non-recording, and therefore did not require to be fed with endless supplies of paper like the more modern inventions. At a comparatively early stage of telegraphic history, however, paper began to be used for the purpose of recording messages. The Bain instrument, in use some twenty years ago, or more, recorded its signals in the shape of blue marks on chemically-prepared paper; and the original Morse instrument indented the signs representing the alphabet on a narrow strip of paper by means of a stile or pointer, and hence the name which has always clung to it—the "embosser." In these days of postal telegraphy paper enters very largely into both the sending and receiving operations on the wires. The extended use of the Wheatstone system has greatly increased the consumption of paper; and it seems improbable that, for some time to come at least, sounding or non-recording instruments will be introduced to such an extent as to materially alter the conditions in this respect. Telegraphic paper is of three kinds, viz., that used for the Morse, Wheatstone, and Hughes instruments respectively. Morse paper, as it is called, is that which is most in use, being equally adapted—so far as recording messages is concerned—to the ordinary Morse and Wheatstone instruments. This paper is used in a narrow strip, about ⅜ths of an inch wide, and is of a greenish tint, so as to be less trying to the sight of the operator than ordinary white paper. It is usually wound on spindles about 4½ feet long and 8 inches in diameter, and afterwards cut into rolls of the width required for the instrument—namely, about ⅜ths of an inch. Of these spindles, each containing upwards of 30 miles of paper, no fewer than 350 per month, or upwards of 4000 per annum, are consumed in the postal telegraph service throughout the country, so that the total annual consumption of the narrow strip must exceed 130,000 miles. The paper coil is fitted to the instrument as occasion requires, and is unwound by means of clockwork whenever the apparatus is started to receive a message. What is known as Wheatstone paper is employed exclusively in the sending process of telegraphy. It is sometimes called punching-paper, because it is perforated full of large and small holes, indicating the different signs in telegraphy, before it is passed through the transmitting apparatus. This paper is white, and is of a rather stronger texture than the ordinary Morse paper, besides being cut up into a slightly wider strip. The coils undergo a preparation in oil before being brought into use, in order that the paper may be more readily acted upon by the perforating machines; and for this purpose as many as 500 gals. of sweet oil are annually consumed in the telegraph department. Nearly 7000 miles of Wheatstone paper are used in the postal system in the course of a year, and this is obtained by cutting up into coils upwards of 300 spindles of much the same dimensions as those of the Morse paper. Until very recently all the paper used throughout the postal system was cut and dressed in the telegraph department in London. The process, in which a steam-engine and several lathes of peculiar construction were employed, was a somewhat novel one, and often engaged the attention of visitors—on one occasion that of the Emperor of Brazil, who carried off a roll of paper as a memento of his visit. A mile of Morse paper cut into the narrow strip required for the instrument only weighs 2 lbs. 3 ozs., while a mile of Wheatstone paper is nearly 1½ lbs. heavier. The Morse paper, after being "written" or printed on, is called "slip," and after being unwound from the instrument, and the signals translated, it is rewound, labelled, and carefully filed away, in case it should be required for reference any time within the three months during which it is the practice of the Post-Office to keep all messages. These slips are a kind of "sword of Damocles" hanging over the head of the unfortunate operator who may chance to have made an error in the transmission of a message, for it need scarcely be explained that they disclose with unerring exactness whether the blunder has been made by the sending or receiving clerk. In a large office like that at St. Martin's-le-Grand many miles of these tape-like records must be constantly on hand, and if they could only be placed side by side with the corresponding messages sorted away in the vaults underneath they might tell a curious tale. The same fate awaits both the "slip" and the messages. At the end of every three months some tons of both are carted off to that mysterious "mill" of Her Majesty's Stationery Office whence no official form or document was ever known to return—in its original shape, at all events. "Pulp" is the condition to which all such matters are reduced; and if the message forms or the "slip" ever find their way back to St. Martin's-le-Grand, it is quite certain that they only return as an old friend with a new face.—*Times*.

To Correspondents.

*** Duly authenticated contributions, theoretical and practical, on every subject identified with the interests of which "The Telegraphic Journal" is the organ, will always command attention. Anonymous correspondence will be wholly disregarded. Literary communications and books for review should be addressed to the Editor; business communications to the Publisher.

THE TELEGRAPHIC JOURNAL.

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UNDERGROUND WIRES.

There are few periods that are so distinctly marked in the annals of telegraphy in England as the famous year 1866, when all the lines radiating away from the Metropolis were swept away in a fearful snow storm in January of that year. A fall of snow, a thaw, another fall, a frost and a severe gale, rapidly succeeding each other, snapped off our overladen poles, and broke our ice-laden wires into such terrible disorder, that one old soldier-lineman pronounced it, with tears in his eyes, to be "worse than the battle of Waterloo." It was felt at the time that the only panacea for such destruction was to be found in underground wires, but the experience in gutta-percha covered wires placed underground was sadly against their further employment on a large scale. The Electric Telegraph Company had in the year 1853 laid down eight gutta-percha covered wires between London, Manchester, and Liverpool, along the London and North Western Railway, but after a few years' experience they had to take them up again. The Magnetic Company, about the same period, laid down similar wires along the Lancashire and Yorkshire Railway, between Liverpool and Manchester, and along the high-roads between Manchester, Birmingham, and London, and northwards of Manchester, with similar results. The Submarine Company laid similar wires with similar results between London and Dover. Hence telegraph engineers became chary of touching underground wires. Yet underground wires were employed with success through our chief cities, and the fact gradually became patent that the early failures were solely due to want of experience. There was nothing defective in the gutta-percha itself. Left in water it appeared indestructible, but exposed to air and light it decayed. Maintained apart from the oxygen of the air its durability was unquestionable. Saturated with coal-tar it perished. Exposed to the sun the conductor lost its concentricity, and its insulation was lost. Testing was unknown, except in a very rough-and-ready way, and the wires were drawn into the pipes in the most ruthless and cruel manner. Horses were used for this purpose in the streets of London, and the order was—"Pull them in, never mind how, but pull them in." Thus the wires became full of injuries and faults. Jointing was scarcely known. Dirty, greasy hands were satisfied in making a joint that externally pleased the eye, but the searching test of the current was not thought of. Even the manufacture was in its infancy. Now, thanks to the improvements of Truman, Chatterton, and others, the manufacture is well-nigh perfect. Joints are scientifically made, tests are of the most delicate and penetrating character, the wires are drawn in with tender and nurselike care, the wire itself is carefully prepared, protected, and never exposed, its enemies—such as coal-tar—are known and carefully eschewed, and there is every indication that underground wires can be made as indestructible as submarine cables. Confidence is being restored, and the system is being gradually extended. In 1871 Mr. Culley laid down fourteen wires between Manchester and Liverpool. There are over 3,000 miles of underground wire in London.

There are many reasons why underground wires should be more extensively employed. Nothing can be more unsightly than the network of overhouse wires that destroy the skyline of our streets. Underground wires are not only sightless, but, away as they are from all atmospheric disturbances, they are free from accident, and are almost entirely free from interruption. Their repairs are consequently few and far between, and their cost of maintenance is therefore comparatively small. Moreover, when an accident does occur its locality is so accurately measured by the perfect system of testing now in vogue, that its repair is a matter of ease and rapidity.

But the system is costly, and when underground wires are employed in long lengths, the retarding influence of induction tends to reduce the speed of working; but when it is remembered that the Atlantic cables are now worked with a speed greater than that attained in the first underground wires between London and Liverpool, we may easily surmise that any retardation on our long underground lines will readily succumb to the theoretic knowledge and practical skill of the present day. Indeed the equable condition of underground wires is remarkably favourable to duplex and Wheatstone's automatic system of working. The capacity of such wires so worked is practically equal to that of overground wires of similar lengths.

The decay of overground wires in some localities, such as the smoky approaches to our manufacturing towns, is so rapid that underground wires in such places in the long run become absolutely cheaper. This is felt so much in London that our underground system is being rapidly pushed into the country. Thus towards the west it extends as far as Hounslow; in the south as far as New Cross; in the north beyond Highgate; and

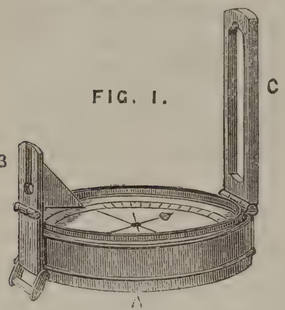
doubtless as our system increases we shall hear of underground trunk lines as far as Birmingham or Bristol.

ON TELEGRAPH CONSTRUCTION.

By JOHN GAVEY, Assoc. Soc. T. E.

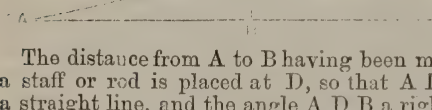
(Continued from page 141.)

FIG. I.



The prismatic compass is, perhaps, the most simple instrument for measuring angles roughly. It is illustrated in the attached sketch, figure 1. A is an ordinary compass box, fitted with a sight vane, C, across which a fine wire is extended vertically. The plate B is provided with a narrow slit, through which the sight is directed, and is fitted with a prism, by which the degrees on the compass card are seen in a line with the wire on the sight vane, the instrument being directed first to one object, so that the wire, when seen through the slit, covers it; the observed reading on the compass scale is recorded, and the difference between that and the reading, when the instrument is turned to the other object, gives the angle which they form with the position of the observer.

Actual measurements of angles are, however, but rarely taken in ordinary telegraph surveying. The angle is generally judged by the eye. It can easily be measured with the chain, thus: giving three positions, A B C, fig 2, it is desired to ascertain the angle.



The distance from A to B having been measured, a staff or rod is placed at D, so that A D C form a straight line, and the angle A D B a right angle. Dividing B D by A B or the fraction $\frac{BD}{AB}$ is the cosine of the angle A B D. A reference to an ordinary table of Sines will give the value of this in degrees, which is half A B C, when A B is equal to B C. When they are not equal, the angle C B D must be found in a like manner, and the sum of the two gives the angle A B C. If the lines A D and D B be measured, the fraction $\frac{AD}{DB}$ represents the tangent of A B D, the actual value being obtained as in the former case.

Levels are judged by the eye, or by the simple use of the ranging or offset staves.

A description of the more complicated surveys needed in an uninhabited country, by means of the level and theodolite, is beyond the scope of the present articles. Those who seek further information on this subject, are directed to the small work by T. Baker, C.E., one of those excellent little rudimentary manuals published in Weale's series.

The officer who surveys should be accompanied by three or four men. It is false economy to stint labour in a survey, for it involves delay, wastes the surveyor's time, and depreciates the ultimate value of the work. He should provide himself, in addition to the foregoing instruments, with some, or all of the following materials:—A spade, a light pointed bar, a can of white paint, and a brush; and if plugs are used, a light hand-cart and small sledge hammer. The spade, paint, and plugs are intended to mark the position chosen for each pole, this being done sometimes by removing a spade-full of soil or "spit," as it is termed—a convenient method with turf; sometimes by a paint-mark—generally a /|\ on the nearest fence; and sometimes by driving in a plug exactly at the point where each pole must stand. These plugs consist of any description of timber that is available, cut about 18 inches long by 2 inches square, and pointed at one end. Old poles or any waste wood will serve for these.

We prefer the paint and the plug combined, for the first catches the eye very readily if the latter is hidden by vegetation, and this indicates to the workmen, without doubt, the exact point where the holes must be dug. The paint-marks, too, are very permanent, standing out clearly for a long period; but both the others are in some localities very evanescent, the "spit" being filled up or grown over, and the plugs being pulled up by children for amusement.

Everything being prepared, and the position for the terminal pole being fixed upon, the men are disposed in readiness for the start. If it be a straight length of road that presents itself, a guiding or ranging rod is erected at its furthest extremity, and the measurement is commenced from the point where the terminal pole is to be erected. When the men have measured the distance that has been fixed upon as the span for straight lengths, an offset rod is held vertically at number two pole, and a man standing at the first pole, with another rod, ranges the second one, until it is in a straight line with the distant signal previously erected. The distance of the pole from the hedge, wall, fence, or other convenient boundary, is then measured at right angles to the line and entered in the offset column of the survey book, together with the other particulars detailed below.

The position of the pole is marked by either of the means above mentioned, that may have been selected, and the men start again, measuring towards number three pole. Number one man moves to number two pole, gives the range to number three, the particulars are again entered, and so on. If this is carefully done, the poles when erected will be found to be in a straight line, so that standing behind one, and looking in the line of the wires, all the others are invisible.

If the road curves, the same process is repeated, the spans being, however, shortened according to circumstances.

The surveyor judges the acuteness of the angle by estimating the length of the perpendicular A D in fig. 2, and in accordance with this he varies the span, provides for larger or heavier timber, or deals with the estimated strain, as circumstances direct.

The survey-book should contain all the information necessary for the subsequent operations. It is not generally customary in England to prepare a plan of the line.

The necessary particulars are simply entered in columns ruled for the purpose. The following is an example of one form.

Consecutive No of Pole.	Span in yards.	Length of pole in feet	Dimensions.	Offset in feet.	Stay.	Strut.	Remarks, including way leave particulars.

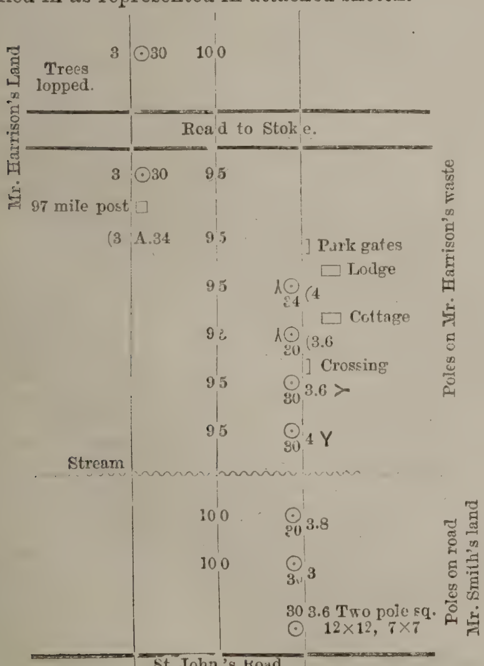
Most of the headings themselves explain their utility. The column for "dimensions" need only be filled in where specially heavy or square timber is needed. The "remarks" should include the name and address of owner and tenant, in all cases where poles or their supports, have to be fixed on private property. All the consents for such are to be obtained before the work on any given section is commenced.

Distinguishing objects, such as mile posts, crossings, &c., should be entered in the "remarks." They form a convenient check against possible error arising from missing an entry, either in laying out stores, or in subsequenty erecting poles.

The survey book sketched out might, however, be readily replaced by a plan, which by the use of a few symbols, might give the whole of the details required for constructing the line, without involving further labour than the present system does.

This would be found of considerable service for office reference after the line was completed, for it would be directly comparable with the complete Ordnance maps, and exact facts referring to any portion of the line could be obtained at a glance.

For this a narrow book about 12 inches long is needed, with three parallel lines ruled down the centre of each page. These lines represent the road to be followed, and the particulars may be filled in as represented in attached sketch.



The outer lines represent the road boundaries, and the middle one, the centre of the road. Curves are represented by the angles < > according to the direction. These angles may be made to express the amount as well as the direction of the pull on each pole. Spans are measured and represented along the centre line. The poles are shown by dots inside the outer line which bounds whichever side of the road may be adopted, the length being entered close to the dot. Offsets are entered outside the corresponding line. Poles are represented thus A, and strutted poles thus Ⲗ, whilst stays have a line added to the angles denoting the curve thus ≻. Notes as to property and consents, together with names of roads, streams, and other particulars, are written in the margin.

A convenient scale for such a plan would be the usual division of a foot into 100 parts, which appears on the edge of an ordinary foot rule, although a flat rule so divided would of course be used in practice.

It would be convenient for each page of the survey book to contain particulars of one mile of line. On this scale with a book 12 inches long, each one hundredth division would represent a length of 20 yards, and space would thereby be given for all needed particulars, the mile length occupying a little over 10½ inches of the page. Naturally, any desired scale might be adopted in practice.

A few general remarks as to the principles to be observed in laying out the line, may be allowed to close this division of the subject.

First and foremost comes the question of spans, or in other words the number of poles to be used per mile. This, as might be imagined, varies very greatly according to the views of the engineer and the varying local circumstances.

In the early days of telegraphy, poles were planted regularly 55 yards apart, from end to end of the line, thus giving 32 poles to the mile. The spans were, however, gradually lengthened, until as few as ten poles, giving spans averaging 176 yards, have been used.

In the present day, however, the number of poles for roads may be said to vary from 20 to 26 per mile, and although in some special cases more have been used, the latter number may fairly be regarded as a maximum. In straight lengths poles can be placed from 70 to 100 yards apart, according to the number of wires the lines will have to carry, but on curves this distance frequently has to be reduced to 60 yards. It must always be borne in mind, that increasing the number of poles per mile, whilst giving greater stability to the line, decreases the insulation, by multiplying the points of leakage. The mechanical advantage therefore involves an electrical disadvantage, and judgment must be exercised to obtain the mean of both.

In laying out the line, great care must be taken to set the poles well clear of all road traffic, so that there may be no danger of vehicles running against them in the dark. They should be clear of watercourses, so as not to impede the drainage of the road. The line of wire generally has to follow the windings of the road more or less, but in some cases where there is ample waste, a choice exists as to the method of passing the curved portions. Either the line can be placed symetrically with the curve, thus forming, as it were, a concentric arc,

each pole taking an equal amount of the lateral strain; or two points being taken at the extremity of the curve for poles, which will bear all this strain, the line is struck straight across, forming a chord to the arc. With a slight curve the latter is the most advantageous method, other things being equal; with sharp curves the former becomes imperative.

All poles placed at angles should be entered for struts or stays; struts when the direction of the pull is from the thoroughfare, stays when to it. As a rule stays are preferable to struts; they are more economical, more efficient, and more sightly, but it is not well to use them in the former cases, as they become invisible on a dark night, and dangerous to vehicles passing by. Struts may be replaced by A or double poles, a subject treated more at length further on. The side of the road chosen must depend to a great extent on the waste ground available, on the number and size of the trees lining the banks, on the proximity of houses, &c., so that frequently these considerations leave no alternative which side shall be occupied. When there is no room for choice, however, that side which, on tortuous roads, is the inside of the curve, or which causes the strain to be from the road, involves less danger of a wire obstructing the thoroughfare through any breakage. With heavy lines, however, in which all such poles are stayed or strutted, this choice, by substituting struts and A poles for stays, makes the line more costly, and less sightly. When poles are well stayed, and the line constructed with all modern improvements, there should be little danger of wires dropping across the thoroughfare. Frequent crossings of the highway, should, however, be avoided, as however well constructed a line may be, it cannot be insured from a wire breaking by frost, and such breakages may become an indefinite source of danger. Generally the side with the most room, in the shape of waste ground, or good banks, and the fewest trees and houses, is that to be selected. Poles should not be so planted as to carry wires directly over chimneys, as the smoke will, inevitably, cause them to rust and break away quickly at such points.

The height of the poles is another matter for careful consideration. The main or average height of poles now used on trunk roads, is 28 or 30 feet. At crossings, gateways, &c., a greater length must be used, dependent on circumstances. Where there is wheeled traffic passing under wires, a minimum height of 20 feet between the lowest wire and the ground should be maintained. Allowing a foot between each vertical wire, two feet for the dip if in the middle of a span, the depth in the ground plus 20 feet, will, in such cases, give the minimum height. When rising or falling from one length to another, violent extremes should be avoided, as giving an usightly appearance to a line. Poles should vary by regular increments of four or six feet. In towns and villages the greatest difficulties an engineer has to encounter are to be met with, and herein he shows his tact and judgment most to advantage in overcoming artificial objections. If the line has to be carried through on poles, he obtains a plan of the town, and mounts the most lofty eminence available, which gives him a bird's-eye view of the whole locality. There he traces his course, seeks the least fashionable quarter of the town that is available, uses lofty poles, chimney stacks, and occasionally spires, and avoids, whenever possible, fixing poles on roofs. The line should be kept well above the windows of dwelling houses when passing in front of them, and should be erected so as not to impede the action of fire escapes. General instructions can scarcely be laid down for carrying open main trunk wires through towns. It is, however, scarcely advisable to attempt to run a large number of heavy wires over very lofty buildings, as, where this is done, it results in continued heavy expense in removals, alterations, and repairs to roofs.

Some main lines have been carried very successfully through towns, with open work, by the use of ornamental iron poles. This is preferable to a resort to underground work, but it is very costly, far beyond that of an ordinary wooden line. In such cases the line of street is generally followed, and the wires are not carried over dwelling houses. The poles are generally fixed in the curb, and are sometimes used as joint telegraph and lamp-posts.

THE QUADRUPLEX TELEGRAPH.*

By F. W. JONES.

Just one hundred years ago George Louis Lesage, of Geneva, constructed a telegraph composed of twenty-four line wires, corresponding to the twenty-four letters of the alphabet, and by the use of frictional electricity and pith balls, succeeded in transmitting intelligible signals over the wires to a distance.

Numberless experiments by different philosophers followed in quick succession with a view of establishing means of rapid communication between widely-separated places, but none of the systems that were devised proved anything more than scientific toys.

It remained for Morse, in 1844, to establish a system which was to stand the test of actual experience.

During the same year considerable activity in experimenting was also manifested in England. The first line of any length was constructed between London and Gosport, on the London and South Western Railway, but it was two years later before lines were extended for commercial purposes.

In our own country, starting with one wire between Baltimore and Washington in 1844, we can now boast miles enough of telegraph wire, owned by the various companies, to encircle the globe about ten times. Chicago had its first wire in 1847, and now the Western Union Chicago office alone works 72 long circuits stretching in every direction to all parts of the country, besides 30 metropolitan and 60 private lines.

So far from adhering to first principles in the use of *twenty-four wires for the transmission of a single message*, the hour is at hand when *twenty-four messages can be transmitted simultaneously over one wire.*

At the present time four messages are sent at the same time a distance of nearly one thousand miles, with the utmost ease and certainty, at the rate of 120 words per minute.

* Read before the meeting of the American Electrical Society, a Chicago, Ill, February 17, 1875.

The wonderful instrument performing this miracle in telegraphy is *The Quadruplex*, an invention of Messrs. Prescott and Edison, electricians. It is based on the same principle as the Bridge Duplex, comprising all its main features, and in order to render a description of the Quadruplex easier and more comprehensible, I will briefly review the duplex system. Authors do not agree in their account of the origin of the duplex; some refer it to Dr. Gintl in 1853. It is well established, however, that experiments were made by the Electric Telegraph Company, of England, in 1853, but their system did not prove of any advantage, and it fell into disuse. About the same time Gintl, Siemens, and Prischen directed their efforts towards perfecting a duplex, and many Russian stations were fitted up with their instruments; but, from the fact that no gain was realized over single transmission, the stations were refitted with the ordinary Morse. Mr. De Sauty, in 1855, successfully worked the Frischen-Siemens system between Manchester and Altringham. *He only accomplished ten words per minute against sixteen by the single Morse.*

In 1856 attempts were made to work the duplex between London and Birmingham, on the Magnetic Company's wires, and the signals were improved by using a condenser; but the experiments ceased, for the reason that Mr. Gordon, of the firm of R. S. Newall and Co., to whom the English patents belonged, did not deem the addition of condensers of sufficient value to warrant the expense of their construction.

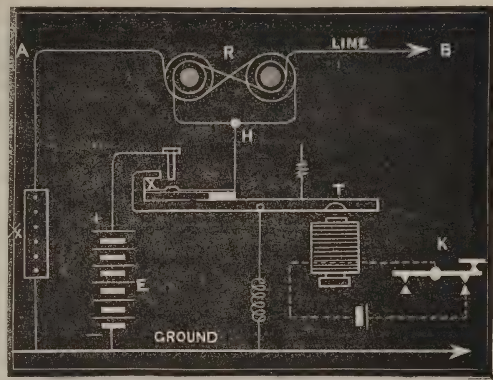
In 1868 the duplex was revived by J. B. Stearns, of Boston, and was actually worked on one of the wires of the Franklin Company. His system, which I will now describe, does not differ materially from those that have preceded it, save in the application of an improved form of double pointed key or transmitter, and, more recently, condensers, whereby long line difficulties were entirely overcome, and the carrying capacity nearly doubled.

A relay is wound throughout with two separate wires, the outer end of one and the inner end of the other are brought directly to the double pointed key. One of the opposite ends of these wires is connected to the line, and the other to a rheostat and ground of resistance equal to the resistance of the line.

The transmitter, or double pointed key, is arranged to be in contact with battery when the lever is depressed, and with ground when elevated—one contact always taking place, through spring contrivances, before the other ceases; thus the line is always on battery or ground.

Supposing B, the distant station, to have his key open, the transmitter, which his key opens, keeps the line grounded through one wire of his relay. When Station A closes his transmitter, the current passes therefrom to the relay, and there divides in two directions; one part goes by one coil of the relay to line, and the other part by the second coil of relay to rheostat and ground. The resistances being equal in these two directions, an equal quantity of current flows through them; but, as they pass oppositely around the core no magnetic effect is produced, and the armature is not attracted from the back stop.

The current arriving at station B passes through one coil of his relay to transmitter and ground,



causing his armature to move forward and close the recording sounder. At this moment, should B close his transmitter he will divide his battery between rheostat and line, as was done at A, and feel no effect from it upon his own armature—one part exactly neutralizing the other; but currents being on the line, there is now double the quantity there was when B was open, consequently through the line coil of either relay, there is more current than there is flowing through the rheostat coils; therefore the cores of each relay become magnetized by this difference, and signals are recorded simultaneously at each station.

As soon as the system was tried on long lines a kick was experienced on the armatures, rendering the signals totally unreliable. This was caused by the discharge of return current through relay, and depended for volume on the static capacity of the line. A familiar illustration of this may be had by supposing a straight pipe to connect two points in the same plane, and at one end of the pipe water is forced through at a high pressure; if the pressure is suddenly removed and the pipe left open at each end, part of the water in the tube will return and empty itself, in preference to overcoming the friction of the distant portion of the tube.

Electricity, in a long and well insulated conductor of large metal cross section, will flow through to the distant end and to ground so long as battery contact is maintained; but let the battery be suddenly removed and a ground substituted, part of the charge at that instant left in the conductor will return to ground in preference to passing through the whole resistance of the line to the farther end. This return is the kick that causes so much vexation to telegraphers. By the use of condensers the kick has ceased to annoy, and five hundred mile circuits are now worked as well as those of one hundred.

It will be readily comprehended that the few coils of fine wire of which a rheostat is composed have not the static or charge capacity of a long line, the metal of one weighing only a few ounces, that of the other perhaps a hundred tons of a superior conducting metal, therefore no return charge or kick is felt from the rheostat; but by attaching to the rheostat a condenser whose static capacity is nearly equal that of the line a charge will be returned from it, at the same moment that the battery charge returns from the line, thus destroying all kick in the relay by neutralizing each other's tendency to magnetize the cores.

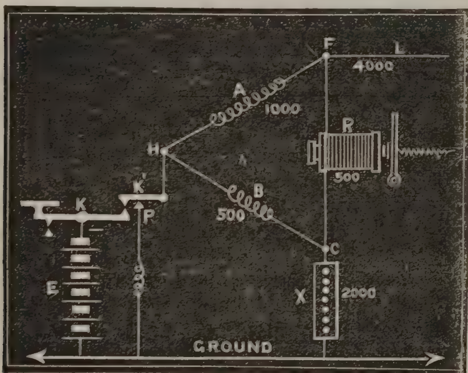
This system can be worked as well with the *same*

poles of battery to line as with opposite or "agreeing" poles. When both stations send positive currents they neutralize each other on the line side, allowing the currents in the rheostat coils of relays at the home ends to move the relay tongues and record the signals, the same as if both currents combined on the line.

Next in order to the differential duplex comes the bridge duplex, founded on the principle of the Wheatstone Bridge. This method was adapted on the Gibraltar and Lisbon cable in April, 1872, by Mr. De Sauty, the electrician of the Eastern Telegraph Company at Gibraltar, at the suggestion of Mr. W. H. Preece, of England.

The length of the cable is 360 nautical miles, and worked by mirror galvanometer and syphon recorder. Mr. De Sauty was from March 16th, 1872, until April 11th of same year before he made it a success, so much trouble being felt from the static discharge; this he overcame by making his rheostat circuit similar to the cable in static capacity, dividing his resistance, and interspersing his condensers, so that they would return a proper charge at the exact time it was returning from the cable. Thus he made himself master of the situation, and has since duplexed other cables, including the Mediterranean cable from Gibraltar to Malta.

In the *Journal of the Telegragh*, Sept. 1st, 1873, is described the bridge duplex as a recent invention of J. B. Stearns, of Boston, and as this system is intimately connected with the quadruplex, a brief notice of the former is necessary to make plain the latter.



The bridge duplex embodies the principle of the Wheatstone balance, wherein a current dividing between two circuits, which are connected by a cross wire or bridge, no current will flow over the bridge if the resistances of the circuits on each side of the bridge are equal, or be the same proportion to each other.

By reference to the diagram it will be seen that when transmitter K is closed the current it sends out will divide at Point H; one part going over line and the other part *via* B and rheostat to ground. Now, if the resistance of these two circuits is equal no current will pass over the bridge wire F C, consequently the relay R will be unmoved. When the current arrives at distant end it divides at F, between the transmitter and rheostat X, in inverse proportion to the resistance of respective routes; the portion passing through F C operates the relay R, and records the signals, and so when distant station closes his transmitter a double amount of current flows through the line, producing unequal tensions in the line and rheostat sides of the bridge, causing a current to flow across each bridge and close the relays, recording signals at each end simultaneously.

Towards the close of 1874 it was noised abroad that a quadruplex had been put into successful operation between New York and Boston by Messrs. Prescott and Edison, electricians. More recently it has been put into actual use between New York and Chicago, through a repeater at Buffalo, and between Chicago and Cincinnati — the former distance being nearly one thousand miles, the latter three hundred miles. As previously stated, it has for its foundation the bridge duplex. In the bridge wire of the duplex there are two relays — one is a common relay of very short cores and moderately low resistance, capable of being affected only by strong currents. The other is a Siemens polarized relay, which is sensitive to feeble currents, and is so constructed as to allow the tongue to be thrown on the back or open stop when a current of a certain polarity passes through its coils, and on the front or closing stop when a reverse current passes. There are two separate transmitters brought into use in double transmission from either end. The double transmitter is a pole changer having one spring connected to line and the other to ground. The contacts with each spring are connected crosswise with the smaller portion of main battery through the spring and lever of the single transmitter, which has an additional section of battery inserted between the lever and its closing contact point. When both transmitters are open the smaller part of the battery will be presented to the line. The current flowing therefrom will divide between the sides of the bridge—one part passing to rheostat and earth, the other passing over line and dividing between the bridge wire and the transmitter ground at receiving end. The portion crossing the bridge will push the tongue of polarized relay on the back stop, but will not affect the common or neutral relay for reasons before stated. If the double transmitter at sending end be closed the same portion of battery is reversed in circuit, deflecting the tongue of polarized relay at distant end to the front or closing stop, thus recording a signal. The second transmitter merely cuts in or out of circuit an increased portion of battery, sufficient to close the distant common relay; and the movements of the first or double transmitter wholly determine the polarity sent to line; when the double transmitter is up and the single one closed the latter cannot record a signal on the polarized relay at the remote station, for the reason that the current is of the wrong polarity; the same effects take place at the home station under similar manipulations at the distant end. Here then is the curious possibility of one operator having his key open, a second his key closed, the third making a dot, and the fourth a dash at the same time, and the respective positions being recognised fully at opposite ends.

Under the supposition that the batteries are divided into proportions of 50 cells and 150 cells the following changes of polarity and quantity will take place on the line during transmission from both stations:—50 plus and 50 minus, 50 plus and 50 plus, 50 plus and 200 minus, 50 plus and 200

plus, 50 minus and 200 plus, 200 minus and 200 plus, 200 minus and 200 minus, 200 plus and 200 plus.

These constant variations and reversals taking place through the relay coils tend to produce in them an unsettled magnetic condition, causing the movements of their armatures to be unsteady and unreliable for signals. To remedy this the bridge wire is supplied with a condenser which is charged by the same currents that work the relays, and so soon as they are withdrawn from relays the condenser discharges before a reversed current reaches them, thus prolonging the signals and preserving a magnetic equilibrium of the cores.

The condensers connected to the equating rheostat require the nicest adjustment to exactly neutralize the static discharge from line. Compared with the differential system the percentage of effective signalling current on the quadruplex is very low, and is divided between two relays in the same circuit, therefore the utmost care is necessary in balancing and arranging the different adjustments to bring out its full value. During actual service it requires great vigilance and an intelligent supervision, else it will fail to even duplex the capacity of a wire. When depended on to do the work of four wires it will be readily seen how grave would be the smallest delay, hence it behoves managers to familiarize themselves thoroughly with every part, in order to render the proper service of the quadruplex to the companies by whom they are employed.

Other methods of quadruplexy have been devised, but have proved of no practical value. That of M. Meyer, of the French Telegraph administration, exhibited at the Vienna Exposition, is the most notable, transmitting four messages over one wire in the *same* direction, but its best performance was only 110 ordinary messages per hour. Dr. H. C. Nicholson, of Mt. Washington, near Cincinnati, has also constructed a quadruplex for transmitting two messages in opposite directions over one wire at the same time. His system is on the differential principle. The outgoing currents passing in opposite directions around the home relay produce no effect on its cores. Two keys are used and are so arranged as to send current to line in the following order: When one key is depressed a positive current of given tension, when the other is closed a negative current of equal tension; when both keys are closed simultaneously a positive current of double the tension of that sent by a single key.

The relay has horizontally, and side by side, two straight cores wound differentially, and at either end are permanently magnetised armatures. One is placed horizontally on a tongue in front of the poles at one end, and the other armature swings vertically on an axis between two semi-circular extensions of the poles opposite those facing the first described armature. Both armatures are so polarized that when one is attracted by a current of certain polarity passing through the coils the other is repelled. In order to balance for work, the distant station is asked to open both keys. This removes his batteries and grounds the line through his instruments. At the home station dots are struck on either key, and the equating rheostat is so adjusted that an even division of current is made through the relay between line and ground, neutralizing all magnetic effect in the cores. Condensers must be used for static discharge the same as in duplex system. The distant station is now asked to dot on positive key, which sends a current attracting the corresponding armature at the home end, closing the local points and recording a signal. Then the distant station dashes on the negative key, closing the armature of home relay at the end opposite the one operated by the positive key, and recording a signal on sounder by contact. When both keys are closed at once the tensions of their batteries are doubled and of positive polarity. This causes a double force to act on the agreeing armature which presses forward a spring, thus closing not only its own sounder, but also the one in the connection with the opposite armature recording signals simultaneously. The weak points of this system seem to lie in the constant and uneven reversals of the current during transmission producing an unsettled condition in the cores; uncertainty of action between the armatures, and the imperfect mechanical contrivance for transferring the operation of the sounder from one tongue of relay to the other.

What may yet come of this system is a problem for future solution. It has worked moderately well on a rheostat circuit of 6,000 ohms, but has disappointed the expectation of its friends on an actual line circuit, probably on account of its infancy and want of a thorough test.

Notes.

The Western Union Telegraph Company have declared their quarterly dividend of 2 per cent., payable 15th July next. The net earnings of the Company for the year ending 30th June, 1875, are set down at 3,912,484.39 dols., the months of May and June being estimated.

On the 8th instant the number of messages passing through the chief London Telegraph Office amounted to 36,550, and on the 9th to 36,544, being the highest number yet dealt with during 24 hours.

The International Telegraph Conference is progressing with its labours. Committees have been formed, whose duty it is to sift the various questions before they are brought under the consideration of the Conference. One of the most important innovations debated in the first few conferences has been the proposal to introduce urgent messages which would take precedence of ordinary messages in international telegraphy, and would, of course, be subject to a higher rate of payment. Another important proposal aims at the adoption of ten-word messages for European telegraphic correspondence, with gradation by the same or a less number of words, or by single words. Other modifications have also been proposed, having for their object the reduction of the existing minimum number of words, with a corresponding reduction

in price. At the same time entertainments of various kinds continue to be organised in honour of the delegates. Amongst other places of note, the Central Telegraph Station at St. Petersburg has been visited. One thing in connection with this establishment will be interesting to many of our readers. The young ladies employed on the telegraph staff wear a kind of uniform dress, green, with orange-coloured piping, cut to resemble a high double-breasted waistcoat. It strikes us young ladies on the London staff will not view this idea with any great amount of favour; at all events, we do not anticipate its speedy adoption by them. The telegraphists (men) are also in uniform of a military type. Sir James Anderson, Managing Director of the Eastern Telegraph Company; Mr. Clare, Secretary of the Submarine Telegraph Company; and Mr. Andrews, of the Indo-European Telegraph Company, have recently arrived to take part in the Conference.

The Sultan of Zanzibar visited the General Post Office, and inspected the telegraph branch of the establishment. Lord John Manners and Mr. Scudamore received the Seyyid, the latter pleasingly bringing under his visitor's notice all the many interesting features of the building. Being invited to send a message, the Sultan addressed the following enquiry to his consular agent at Aden, "What is the latest news from Zanzibar?" and in a short time received the following reply, "Nothing of importance—all well. Your message and letter sent to-day per Coconada to Zanzibar—compliments." Having recorded the fact that on the 18th day of June, 1875, he, Seyyid bin Saed, had visited the telegraph department of the English General Post Office, the distinguished visitor took his departure. The postal department was not inspected, because at that hour the several operations which make it attractive were in abeyance.

At a recent race meeting over 400 messages were received from London in one batch with only one stoppage, for fresh paper, by Wheatstone Receiver.

THE cable between Punta Rassa and Key West (U.S.), announced in our last as having been interrupted, is repaired, and messages are forwarded as usual.

THE new cable making at the Silvertown Works, to duplicate this section, is nearly completed, and will shortly be despatched.

THE Eastern Telegraph Company (Limited) announce that, subject to the final audit, the accounts show a balance available for dividend which will enable the directors, at the general meeting on the 13th July, to recommend the declaration of a final dividend of 2s. 6d. per share, making, with the previous payments on account, a dividend for the year ending 31st March of 5 per cent., carrying to reserve a balance of £36,000.

RESISTANCES AND THEIR MEASUREMENT.

By H. R. KEMPE.

XVII.—*Measurement of Resistances by fall of Charge.*

ONE principle of this method of measurement is that of observing the rate at which a charged condenser of a known electrostatic capacity discharges itself through the unknown resistance, and calculating the resistance from a formula which we are now about to obtain. The elements with which we have to deal, are capacity (farad), resistance (ohm), quantity (vebu), time (second), and potential (volt).

Let us suppose the condenser has an electrostatic capacity of C farads, and is charged to a potential of V volts so that it contains Q vebus (equal to V C) of electricity, and is discharging itself through a resistance of R ohms during 7 secs.

Now the quantity of electricity in the condenser at starting is Q vebus.

Then if we take a very short interval of time t we may consider the discharge, which really continually varies, to continue to flow throughout that time t, at the same rate as it had at the commencement of the time, and the smaller t is taken, the more accurate will be the result. Thus since the quantity escaping is directly proportional to the potential driving A out, and to the time during which the escape occurs, and inversely proportional to the resistance through which the escape takes place, the quantity escaping will vary as—

$$\frac{V\,t}{R} \text{ that is, it equals } \frac{V\,t}{R}\,K$$

where K is a constant to be determined.

Now the units are so made that a condenser of 1 farad electrostatic capacity charged to a potential of 1 volt, that is containing 1 vebu of electricity, will commence to discharge itself through a resistance of 1 ohm, at the rate of 1 vebu a second. That is to say—

$$1 = \frac{1 \times 1}{1} K, \text{ therefore } K = 1.$$

The quantity escaping during the interval of time t in our problem is therefore—

$$\frac{V\,t}{R}$$

The quantity remaining in the condenser will be—

$$Q - \frac{V\,t}{R} = Q - \frac{V\,C\,t}{C\,R}$$
$$= Q\left(1 - \frac{t}{C\,R}\right)$$

Again since this is the quantity at the commencement of the 2nd interval, that at the end will be—

$$\left[Q\left(1 - \frac{t}{C\,R}\right)\right] \quad \left[\left(1 - \frac{t}{C\,R}\right)\right]$$
$$= Q\left(1 - \frac{t}{C\,R}\right)^2$$

and that at the end of the nth second will be—

$$Q\left(1 - \frac{t}{C\,R}\right)^n = q$$

Now let these n intervals of t seconds equal T, so that $n\,t = \mathrm{T}$. Now we have seen that the smaller t is the more accurate will our results be. Let us then make $t = o$ and $n = \infty$, so that $n\,t$ still $= \mathrm{T}$, then we shall get a perfectly accurate result, and the amount remaining at the end of time T will be—

$$q = \mathrm{Q}\left(1 - \frac{\mathrm{T}}{\mathrm{N\,C\,R}}\right)^n$$

where $n = \infty$

To evaluate q put

$$\frac{\mathrm{T}}{n\,\mathrm{C\,R}} = -\frac{1}{\mathrm{X}}$$

so that

$$x = \infty \text{ when } n = \infty$$

then

$$q = \mathrm{Q}\left[\left(1 \times \frac{1}{x}\right)^{x}\right] - \frac{\mathrm{T}}{\mathrm{C\,R}}$$

when $x = \infty$, but when this is the case the expression within the square brackets is known to be equal to z, thus—

$$\frac{q}{\mathrm{Q}} = {}^{2} - \frac{\mathrm{T}}{\mathrm{C\,R}}$$

thus—

$$\frac{\mathrm{T}}{\mathrm{C\,R}} = \text{by}_{\,2}\frac{\mathrm{Q}}{q}$$

therefore—

$$\mathrm{R} = \frac{\mathrm{T}}{\mathrm{C}\ \text{by}_{\,2}\frac{\mathrm{Q}}{q}}$$

but—

$$\frac{\mathrm{Q}}{q} = \frac{\mathrm{V\,C}}{v\,c} = \frac{\mathrm{V}}{v}$$

where v is the value of the potential corresponding to the value q of the quantity, thus—

$$\mathrm{R} = \frac{\mathrm{T}}{\mathrm{C}\ \text{by}_{\,2}\frac{\mathrm{V}}{v}}$$

where, as stated at outset, t is measured in seconds, c in farads, and r in ohms. V and v, although measured at the outset in volts, as they now appear in the form of a proportion, the unit in which they are measured is immaterial, and this constitutes one of the values of the formula.

In practice C is usually measured in mirrofarads ($\frac{1}{1000000}$ farad), and consequently R will, in such a case, be measured in megohms (1,000,000 ohms).

Example.

A charged condenser of ·3 microfarads capacity gave a discharge deflection of 300° when full, after being recharged and allowed to discharge itself through the resistance for 60 seconds, the discharge deflection given was 200° to determine the value of the resistance.

$$\mathrm{R} = \frac{60}{\cdot 3 \log.\frac{300}{200}} = 126 \text{ megohms.}$$

Inasmuch as the fall of charge would be rapid through a low resistance, this method is only applicable to high resistances like the dielectric of a cable. When the insulation resistance of a cable is measured by this method, the result obtained is the mean of the resistance which it has at the beginning, and which it has at the end of the experiment, as *electrification* goes on, the whole time the experiment is being made.

The A cable acts both as the condenser and resistance. We should just, therefore, have to determine its electrostatic capacity, which we should do by the ordinary method of comparing the discharge deflection obtained from it with that obtained from a standard condenser.

If we know the potential the cable has when full charged, and also its potential after a certain time, we can determine the potential it will have after any other time.

Now a charged cable loses equal percentages of its charge in equal times, that is to say—if, for example, 5 per cent. of its charge during the 1st second, it would lose 5 per cent. of *what remained* in the second second.

Let V be the potential at first
v ,, ,, after 1 sec.
v_1 ,, ,, ,, t_1 ,,
v_2 ,, ,, ,, t_2 ,,

and let us suppose the charge lost $\frac{1}{\mathrm{N}}$ th of its potential during the 1st second, then potential left at the end of first 2nd will be—

$$\mathrm{V} - \frac{\mathrm{V}}{n} = v = \mathrm{V}\frac{v}{\mathrm{V}}$$

potential left at end of 2nd section will be—

$$v - \frac{v}{n} = v$$

but from last equation—

$$n = \frac{\mathrm{V}}{\mathrm{V}\,v}$$

therefore substituting j we get—

$$\frac{v^2}{\mathrm{V}} = \mathrm{V}\left(\frac{v}{\mathrm{V}}\right)^2$$

and consequently potential left at the end of t_1 seconds will be—

$$\mathrm{V}\left(\frac{v}{\mathrm{V}}\right)^{t_1} = v_1$$

and also—

$$\mathrm{V}\left(\frac{v}{\mathrm{V}}\right)^{t}{}_{2} = v_2$$

therefore—

$$t_1 = \frac{\log\frac{v_1}{\mathrm{V}}}{\log\frac{v}{\mathrm{V}}}$$

$$t_2 = \frac{\frac{v_2}{\mathrm{V}}}{\log\frac{v}{\mathrm{V}}}$$

that is—

$$t_2 = \frac{\log\frac{v_2}{\mathrm{V}}}{\log\frac{v_1}{\mathrm{V}}}\quad t_1$$

The logarithms may be either natural or common ones, thus, for example, if the potential at first was 300 (V) and after 20 secs. (t_1), it fell to 200 (v_1), after what time would it fall to 100 (v_2)?

$$t_2 = \frac{\log\frac{100}{300}}{\log\frac{200}{300}} \times 20 = 54 \text{ secs.}$$

It being usually required to know the time the charge in a cable will fall to half tension the formula becomes

$$t\,z = \frac{\cdot 30103}{\log \frac{V}{v_1}}$$

It will be readily understood that the formula for determining the resistance from fall of charge will also enable us to determine the electrostatic capacity of a cable from fall of charge. In this case the formula would be

$$c = \frac{t}{R \log \frac{V}{{}_2v}} \text{ minufarads}$$

The connections for making either of these tests for a cable would be precisely the same as those used in making a capacity test. The second trigger of the discharged key described would here come into use. Having first charged our cable and taken the immediate discharge by pressing down the left-hand key we should again charge it, and this time press the right-hand key down, which would take the battery off but not discharge the cable. After a certain interval of time, which is noted, the left-hand key is depressed, which gives the discharge of the remaining portion of the charge.

(To be continued.)

THE ADJUSTMENT OF MORSE INSTRUMENTS.*

By H. W. JENVEY.

I SHALL endeavour to avoid the theoretic aspect of adjustment as much as possible, and when I do mention it to do so as plainly as I can.

We may divide a Morse instrument into three parts—the relay, the register, and the key.

I.—THE RELAY.

I take this first as being, I consider, the most important part. We all know how important it is when a line is working badly through damp weather, etc., to have a good adjustment of the relay, or, in other words, to get as much power out of it with a given amount of current as possible. I find the best way, on coming to an instrument on a line which I know to be working badly, is to raise the spring to its highest limit, then to screw the magnet as near the armature as possible without closing the local circuit (this may be arrived at by trying the magnets forward and back till the adjustment is just above closing point), and then to adjust down with the spring till I either find some one working, or am assured that the line is silent. After this adjust with the spring for the station sending, unless the adjustment varies very much. Before doing this I should have mentioned that it is most highly important to see that the contact points of the relay are perfectly clean and smooth. They may be made so by taking out the front stop and rubbing the point on a piece of wood till quite bright and clean, and the small platinum plate on the armature should be cleaned from any specks which may be on it with a knife, and rubbed bright. A very fine watchmaker's file is an excellent thing for this purpose. The points, having been cleaned and smoothed, should now be screwed as closely together as possible, without causing the armature to stick. This can be ascertained by opening the key, and then screwing the points as close together as possible without closing the local circuit. These precautions having been taken, and granted that the relay is a fairly good one, the line must be in a bad state indeed if you cannot get signals from the other stations.

The reason why it is advisable to have the spring as tight, and the magnets as near to the armature as possible, consistently with being in adjustment, is that the power developed in the magnets for moving the armature is used to its best advantage, and the power of the spring to draw the armature away, when the key of the sending station is opened, is exercised more immediately than if it were comparatively weak, thereby making the armature follow the action of the sending key in a firm and decisive way.

For, suppose that I am adjusting for a station, and find that I can adjust the magnets $\frac{1}{16}$ of an inch from the armature when I have the spring screwed up to its full pitch, it is evident that it will work much firmer with this strong pull on each side than if I have the magnets half-an-inch off the spring, hanging loose or next door to it, when the pull on each side is almost nil. There is a certain amount of inertia in the armature of the relay, which, in the first instance, is almost entirely overcome by the strength of the spring and attraction of the magnets, but which, in the second instance, is a great deal too much for either to work it. These are, of course, extreme instances, but they serve to illustrate the rule. There is another thing in favour of the way of adjusting that I advise, and that is, that the vibration from the movement of the armature of the register, and any chance vibration in the room, both of which are conveyed by the table to the relay, and shake it, have not nearly the disturbing effect upon the movement of the armature that they have when the relay is loosely adjusted. When the string is too long to allow the magnets to be screwed close up, a piece of it should be taken off. I recollect one of our colleagues coming to me one day and saying, "See what's wrong here; I can't get anyone's writing, yet I think the line's right." This was one of the best working lines in the office, so I suspected something wrong in the adjustment, and found the magnets of the relay far away from the armature, and the spring hanging like a slack clothes-line. I screwed up the points, the spring, and the magnets, and behold writing came admirably. I found afterwards that he could not even get his own writing on the instrument. The fact was, that as he had the instrument adjusted neither the spring nor the magnets had sufficient strength to stir the armature, while every vibration in the room set the instrument jarring like a clock running down.

It is advisable, also, to see that there is a good contact between the pivot points of the armature and the brasses which hold them, so that the local current may be uninterrupted there. This is a frequent cause of an instrument working badly. It is best, also, to have the position of the armature as perpendicular as possible, as there is less liability to stick.

I think we may now turn our attention to number

2.—THE REGISTER.

The same remarks which I have made about the relay, with regard to the nearness of the magnets to the armature, are applicable here. The magnets should, by some means, be made perfectly firm, and the armature adjusted down to them, rather than the magnets to the armature. If the magnets are not firm they will jump and give a drubbing sound when the instrument is working. The spring may be tightened according to the liking of the operator for a hard or soft sound, as

* Read before the Telegraph Electrical Society, Melbourne.

the tighter the spring the stronger the stroke against the back stop. There is one great difference between the adjustment of a relay and a register; and that is, that the adjustment of a relay is constantly varying from the different kinds of weather and other causes, but the adjustment of, at all events, the magnets of a register need never be shifted after they are once placed at their maximum point of attraction consistently with the armature working well. Any subsequent variation in the attractive power of the magnets, which will be caused by a weakening or strengthening of the local battery, may be compensated for by shifting the screw of the spring as may be required. If a line is working badly, and a fine and high adjustment of the relay is necessary, the armature will often jar. This arises from the vibration caused by its movement shaking the armature of the relay to and fro, and opening and closing the local circuit, independently of what is being done in that way by the sender. The best way to avoid this is to screw the back-stop of the armature of the register down till the beat of it is lessened as to no longer shake the relay; at all events, try to get as near that as possible, consistently with getting a tape mark. This is one reason why ink instruments are preferable to embossers on a bad line, as the register armature will make a mark, and work with less play than an embosser. Where the instrument is an embosser, great care should be taken to keep the steel embossing point exactly in the centre of the groove of the roller, as then the best possible tape mark is obtained, and the sound is less interfered with than if the point grazes or strikes against the roller. Very little care is taken by sound operators, as a rule, to keep a good tape mark, but a little trouble will sometimes repay itself doubly, especially in looking up a message afterwards, as it must be remembered that every time the tape passes through the rollers the previously embossed lines get another flattening, and therefore the deeper the mark at first the better it survives the squeezes it gets afterwards. The discs of ink instruments should be kept perfectly free from accumulations of dust, lumps, etc., and particular care taken that they only sufficiently press the tape to make a mark and no more. If they batter against the steel bar, against which the disc strikes the tape, the edge becomes corrugated and makes a very bad mark, and the sound is also interfered with. In embossers the screws confining the pivots of the armature should be sufficiently loose to let the armature have free play, and sufficiently tight to ensure its remaining in its proper place. Where an instrument repeats on to another by the register, it is of the highest importance to keep the point of the front stop of the register and the contact piece of the register armature perfectly clean, and to close the front and back stop as near as possible without sticking, and without preventing the attendant from hearing when a break occurs.

I may as well remark here that in running tape through it will be found advantageous to be systematic; say, to always have the first line at the top of the tape, and the second next below it, and the third below that, and never to use a tape for more than three lines. The advantage of this will be found on any reference to the tape afterwards.

I should like to express here a dislike I have to the system of regulating the magnets of the register by means of the screw which is provided for that purpose on the latter supplied instruments. I believe it to be not only totally unnecessary, but a nuisance, and if the magnets are jammed down tight and left there the instrument can be adjusted to them. Lastly we arrive at

3.—THE KEY.

There is little to be said about this beyond pointing out the necessity of having the contact points perfectly bright and smooth. The degree of pull in the spring and the distance between the points are matters of taste; but I think that better sending is obtained in most cases from a well opened key and a moderately slack spring than from a key jammed almost to the sticking point, and a spring with a pull of some pounds more or less. Care should be taken that the key works very freely on its pivot; otherwise, it will retard freedom in sending.

To sum up: the pleasure and ease in working derived from a little care in adjusting repay any trouble undertaken, and to point out a few main principles of adjustment is my apology for having read this paper.

Mr. D. J. McGauran, at the conclusion of the meeting, exhibited a model of his own construction, showing the working of the duplex system of telegraphy.

The model worked admirably, and excited a great deal of interest.

INDIA-RUBBER.

The composition of India-rubber, as determined by Faraday, is 87·2 per cent. of carbon and 12·8 of hydrogen.

In its natural state it forms part of the milky sap of various species of trees, which are to be met with in tropical regions, its synonym, caoutchouc, being derived from the caoutchouc tree, which is chiefly to be found in Central America, and was for some time the source whence the main supplies of the article were drawn. The trunk of the tree is periodically pierced—in some instances as frequently as once a fortnight—and the sap as it issues is either caught in vessels placed for the purpose, or allowed to accumulate in a hole dug round the foot of the tree. The liquid may be prepared for export in two ways. Either balls of clay are inserted into it, then passed over a fire, until the India-rubber which they have taken up hardens, re-dipped, and have the same operation repeated upon them, until a certain thickness is obtained; or a piece of wood is employed, around which the sap accumulates, and from which it is detached after a certain volume has been acquired. The purest India-rubber is prepared in the latter way. With the clay-balls, impurities in the shape of sand, pebbles, &c., are unavoidable.

The first process to which the raw material after its importation is subjected has for its object the removal of all the impurities which have become mixed with the natural gum as it ran from the parent tree. This is effected by sawing it up—after being softened by immersion in hot water—into small pieces of about an inch and a-half square, pressing these betwixt two horizontal cylinders, and keeping a constant stream of water flowing upon them. The irregular sheets into which they are ultimately formed are then dried by being hung where a free circulation of air can take place.

These sheets are then kneaded and heated for the purpose of reducing them to a perfectly homogeneous mass. This is done by means of a horizontal cylinder, along the whole length of which runs a shaft provided with a series of sharp pointed teeth disposed of in alternate rows. Into the free space of the cylinder the India-rubber is introduced, and the entire mass assuming a rotary motion, under the influence of these teeth, is masticated by them until perfect homogeneity is attained. The cylinder was usually formed with a double casing, heated by steam, in order to facilitate the process of mastication, but this is now being abandoned, as the mechanical heat developed is found of itself to be sufficient for the work. By raising the temperature too much, great danger is incurred of rendering the India-rubber soft and viscous, and thereby lowering its value for electrical purposes to a very material extent.

The last operation in preparing the pure rubber is to pass it betwixt the compressing cylinders, which are hollow, heated internally by steam pipes, and arranged horizontally in couples. From betwixt these it finally issues in the shape of a smooth compressed sheet of close texture.

Pure India-rubber is colourless and transparent. It

possesses the power of absorbing water, cannot be dissolved by any dilute acid, nor even by the strongest alkaline solutions; although concentrated sulphuric acid, especially if aided by heat, and nitric acid lead to its decomposition. The best dissolvent known that can be employed is the bisulphide of carbon, with an addition of 5 per cent. of anhydrous alcohol. The elasticity of India-rubber is its main characteristic. At the ordinary temperature it is very elastic, but if cooled it gradually loses this property, until when 35° F. is reached it has disappeared altogether. When heated to about 350° F. it assumes a viscous condition.

Various attempts have from time to time been made to introduce India-rubber as the insulating covering for underground or submarine telegraph wires in place of gutta-percha; but none have been attended with success, leaving out of sight for the present Mr. Hooper's method, which is reserved for future notice. India-rubber possesses several undoubted advantages over gutta-percha, but they are unfortunately more than counterbalanced in the case of pure rubber, at least, by corresponding disadvantages which still remain to be surmounted. Of the advantages of pure rubber the two most important are—

1. Its high insulating power. The resistances of gutta-percha and India-rubber have been made the subject of an immense number of most careful experiments; and although many different results have been obtained, they all agree in assigning to India-rubber, under ordinary circumstances, a higher insulating power than to gutta-percha.

2. Its low specific inductive capacity. Mr. Fleming Jenkin has determined that of gutta-percha to be 4·2, that of india-rubber to be 2·8, taking air as the standard.

Against these are to be urged, amongst other points:

1. The power which india rubber possesses of absorbing water. This is far more manifest in fresh than in salt water, but in both India-rubber offers much greater facilities for absorbtion than gutta-percha.

2. The extreme difficulty of making a sound reliable joint in an India-rubber core. Various methods have been tried—the tapes, the form in which the India-rubber is applied, are wound round the wire, and then consolidated by being immersed in boiling water. In some cases solvents have been applied to join them together. Neither of these methods can be adopted with safety—deterioration of the rubber sets in with both. The plan which met with most favour was that applied by Mr. Siemens, of forming the joint by the adhesion of freshly-cut surface of the tapes subjected to pressure. Yet even this cannot be regarded as a success.

3. The sensitiveness of pure rubber to the variations of temperature is a great drawback to its employment; at low temperature its elasticity, as before remarked, disappears.

In order to overcome as far as possible these objections to the employment of pure India-rubber, *vulcanised* India-rubber has been made use of. It is simply a compound of the pure rubber with from 2 to 3 per cent. of sulphur. In its raw condition India-rubber would appear to consist of two parts—the one compact and elastic, resisting all attempts at solution; the other semi-liquid and readily disolved. Both are well defined, and it is to the latter element that the pecular behaviour of India-rubber under the influence of cold, or when raised to a high temperature, is to be attributed. To obviate this is the object aimed at by the introduction of sulphur. It is partly attained, for not only does vulcanised india-rubbed show less facility for the absorption of water, but it resists alike the extremes of heat and cold, preserves its elasticity under these circumstances, and refuses to be decomposed. Mr. Siemens' experiments upon the relative absorptive powers of gutta percha and India-ubber gave the following results:—

	In fresh water.		In salt water.
Raw India-rubber	25 per cent.	...	3 per cent.
Vulcanised India-rubber	10·14 ,,	...	2·9 ,,
Gutta percha	1·5 ,,	...	1 ,,

But the difficulty of making a proper joint has not been surmounted.

On the other hand, vulcanised India-rubber, though not affected by temperature like the pure rubber, has a great drawback which the latter does not seem to possess. In contact with the copper wire, it in time assumes a viscous condition, and, under pressure, becomes practically useless for insulating purposes. To resist this, the copper wire is tinned before the india-rubber is wrapt around it.

Taken all in all, gutta percha seems destined to hold its own, as the insulating material in underground and submarine telegraphy for many years to come. In our next number we shall touch briefly on its manufacture and the various properties possessed by it.

THE LIGHTNING ROD MAN.

He drove his team close up to the fence, got down, and rapped at the door. The widow Gilkens opened it, when he said: "Mrs. Gilkens, I am cognizant of the circumstances by which you are at present surrounded, left as you are to trudge down the journey of life through a cold and heartless world—no longer sustained and encouraged by the noble one to whom you gave the treasures of your heart's affection, and bowed down by the manifold cares and responsibilities incidental to the rearing of eight small children on forty acres of sub-carboniferous limestone land; yet, Mrs. Gilkens, you are aware that the season is now approaching when dark, dismal, dangerous clouds, at frequent intervals, span the canopy of heaven; and when zigzag streaks of electricity dart promiscuously hither and thither, rendering this habitation unsafe for yourself and those dear little ones; hence, therefore, let me sell you a copper wire, silver tipped, and highly magnetic lightning rod."

The woman staggered back a few paces and yelled: "Narcis! unfasten old Crouch!" In another instant a savage buildog came darting round the corner of the house with bristles up, thirsting for gore. The dog had already mangled a machine agent and a patent soap man, and was held in great esteem by the better class of citizens for his courage and service; but when his eye met the hard, penetrating gaze of Mr. Parsons, his chops fell, and he slinked off and hid in the currant bushes. Then the man said: "My dear lady, you seem to be a little excited. Now, if you will allow me to explain the probably inestimable—"

"Dern ye, I know what will start ye," said Mrs. Gilkens, as she reached under some bed-clothing, and brought forth a horse pistol; but owing to the shattered condition of her nerves, her aim was unsteady, and the charge of buckshot missed save where a few scattered ones struck his cheek and glanced off. A hard metallic smile spread over his countenance, as he leaned his shoulders against the door frame, and again commenced: "My dear madam, such spasmodic manifestations of your disinclination to make a judicious investment of a few paltry dollars—"

"Hi—eo!" shrieked the widow, and collapsed into a kind of jerking swoon, and before she had recovered a highly magnetic lightning rod decorated her humble domicile, and Parsons had the blank note filled out already for her signature.—*Madison (Ind.) Courier.*

To Correspondents.

*** Duly authenticated contributions, theoretical and practical, on every subject identified with the interests of which "The Telegraphic Journal" is the organ, will always command attention. Anonymous correspondence will be wholly disregarded. Literary communications and books for review should be addressed to the Editor; business communications to the Publishers, 10, Paternoster Row, E.C.

THE TELEGRAPHIC JOURNAL.

Vol. III.—No. 59.

ARBITRATION.

There is no question that interests English telegraphists more than the rise and progress of the Post Office Telegraph system. It is the largest self-governed system in the world. It has over 106,000 miles of wire, and over 5,000 stations open to the public. Its revenue is £1,300,000. It is in intimate alliance with all the railway companies on the one hand, and, by means of its cables, with all the continental nations on the other. Though financially it has not yet proved a success, in every other sense the British public are well satisfied with their bargain, and with the efforts that have been made to make postal telegraphy cheap, rapid, and accurate.

When the transference of the telegraphs to the State was determined upon, it was found that there were not only several telegraph companies to be purchased, but many railway companies, who not only carried on telegraphic trade on their own account, but who possessed beneficial interests in the poles and wires erected by the telegraph companies on their lines. The terms of purchase and compensation were arranged by negotiation with all the telegraph companies and with several railway companies, but the remainder of the railway companies, either from want of time or of inclination on their part, were left to be dealt with by arbitration. The 9th Section of the Telegraph Act of 1868 fully detailed the conditions under which these railway companies were to be compensated for the loss of their privileges. The railway companies to be settled were scheduled. They were the London and North Western, the Midland, the Lancashire and Yorkshire, the Great Northern, the Manchester, Sheffield and Lincolnshire, the North Staffordshire, the Great Eastern, the London, Brighton, and South Coast, the Metropolitan lines, and some Scotch railways. The Scotch railways, the Brighton, and the North Western have been settled by agreement. The others have chosen to go to arbitration.

The Great Eastern is the only case that has been heard and settled. The Lancashire and Yorkshire claim has been heard, and is now under consideration. The claims that have been submitted have been fabulous in their amount, and the anticipations of the companies have been so extravagant that unpleasant rumours have for some time been current as to the additional capital sums that would be required to satisfy these claimants. The Great Eastern award has, fortunately, dissipated these rumours. The umpire was the Recorder of London, Mr. Russell Gurney, and the case has been under consideration for many months. The railway company claimed a capital sum of £412,000, with interest at 5 per cent. from the 30th of June, 1874, and an annual payment for way-leave representing, if capitalized, altogether over £500,000. Of this exorbitant demand, they have received £73,315, and an annual payment of £200 a-year. The costs of the company in preparing their claim were over £12,000, and this sum has been taxed down to £3,000.

It has been frequently asserted that the telegraph companies were possessed of nothing more than a lease for a term of years of the telegraph wires, and that it was only after the negotiation between the Government and the telegraph companies that it was discovered that the fee simple reverted eventually to the railway companies, and that it was found necessary to purchase their reversionary interests. Nothing can be more inaccurate. The position of the railway companies was thoroughly and completely explained to the Select Committee of the House of Commons. The Act was passed to deal with all these cases, and it has been found sufficient to meet every case hitherto considered under it. Mr. Scudamore estimated the amount likely to be received by the railways, and there is every indication that his estimate will not be reached.

It is difficult to divine the reasons that can have induced the railway companies to put forward such outrageous claims. Their facts or their mode of calculation must have been very erroneous. Doubtless the enormous strides made by postal telegraphy, and the great increase shown weekly in the columns of the press in the number of messages sent have raised these golconda-like visions. But surely they must have miscounted the growth due to the extension of the system into unprofitable districts, and they cannot have taken the increase in the number of messages due to reduced tariffs as an indication of the growth of profits. Telegraphy under the Post Office management has grown enormously, but while the cost of telegraphing to the public has materially diminished, the cost of working has also increased, and the result is that though the business has grown the profits have contracted.

The ultimate financial success of the undertaking can only be a question of time. The rate of working expenses to gross revenue must gradually decrease, and even now the latter far exceeds the former. As one of our contemporaries observes, the Great Eastern award has an important bearing

upon the financial success of the working of the telegraphs by the State, and it is hoped that it will lead to a speedy settlement with the railway companies that remain to be dealt with.

RESISTANCES AND THEIR MEASUREMENT.

By H. R. KEMPE.

(Continued from page 152.)

XVIII.

THE formulæ obtained in our last article are capable of various modifications, which, however, are more of a fanciful than of an actual practical value.

Thus the formulæ—

$$R = \frac{T}{C \log._e \frac{V}{v}} \quad \text{and } C = \frac{T}{R \log._e \frac{V}{v}}$$

may be simplified if we make $v = \frac{V}{2}$ in which case—

$$\log._e \frac{V}{v} = \log._e 2 = \cdot693$$

therefore—

$$R = \frac{T}{\cdot693\, C} = 1\cdot433 \frac{T}{C}$$

$$\text{and } C = 1\cdot443 \frac{T}{R}$$

This latter formula is found to give the same result as the direct method of measurement, after one minute's electrification, provided the battery be put to the cable for 10 seconds before taking the discharge, and again 10 seconds before insulating it preparatory to taking the discharge reading after the interval of time T.

To obtain the time occupied in falling to half charge experimentally, repeated trials would be necessary, and the time taken in doing this would hardly compensate for the advantage of using a simpler formula.

The object of obtaining the time of fall to half charge is to get a convenient unit for comparison with other cables, and this time of fall is easily calculated from the formula before given, in which the potential after any time may be used, and this is obtained by one observation only.

Another modification of the fall to half potential formula is that of Mr. Preece, viz.—

$$V t_2 = \frac{\cdot30103}{2\cdot000 \log. (100\, n)} t_1$$

where n = percentage of loss in interval of time t_1.

From the equations in article XVII—

$$V \left(\frac{v}{V}\right)^{t_1} = v_1$$

$$V \left(\frac{v}{V}\right)^{t_2} = v_2$$

we can find what would be the potential, v_2, after a certain interval of time, t_2 having given the potential at first, and the potential v_1, after a time, t_1.

We have from these two equations—

$$\left(\frac{v_1}{V}\right)^{t_2} = \left(\frac{v_2}{V}\right)^{t}$$

therefore—

$$v_2 = V \left(\frac{v}{V}\right)^{\frac{t_2}{t_1}}$$

This formula we should have to work out by the aid of logarithmic tables.

And so the formulæ might be expanded and modified to almost any extent to suit various cases, but upon which it is unnecessary to dwell here.

(To be continued.)

ERRATA.

Owing to an accident the proof sheet of the last article was not revised. The following corrections will therefore be necessary.

1st column—

For "vebu" read "veber."

2nd paragraph—For "during 7 secs." read "during 1 sec."

4th paragraph—For "potential driving A out" read "potential driving it out."

2nd column—

For—

$$\frac{T}{n\, C\, R} = -\frac{1}{X}$$

read—

$$\frac{T}{n\, C\, R} = -\frac{1}{x}$$

For—

$$q = Q \left[\left(1 \times \frac{1}{x}\right)^{x} \right] - \frac{T}{C\, R}$$

read—

$$q = Q \left[\left(1 + \frac{1}{x}\right)^{x} \right]^{-\frac{T}{C\, R}}$$

For—

"Expression within square brackets is known to be equal to z."

read—

"Expression within square brackets is known to be equal to e."

for—

$$\frac{q}{Q} = {}^2 - \frac{T}{C\, R}$$

read—

$$\frac{q}{Q} = e^{-\frac{T}{C\, R}}$$

for—

$$\frac{T}{C\, R} = \text{by}_2 \frac{Q}{q}$$

read—

$$\frac{T}{C\, R} = \log._z \frac{Q}{q}$$

For—

$$R = \frac{T}{C \text{ by}_2 \frac{Q}{q}}$$

read—

$$R = \frac{T}{C \log._e \frac{Q}{q}}$$

For—

$$R = \frac{T}{C \text{ by }_2 \frac{V}{v}}$$

read—

$$R = \frac{T}{C \log._e \frac{V}{v}}$$

Two lines below this, for "t is measured in seconds, c in farads, and r in ohms," read "T is measured in seconds, C in farads, and R in ohms;" for "mirrofarads" read "microfarads."

3rd column—

For "The A Cable," read, "A Cable." For "5 per cent. of its charge during the 1st second," read, "5 per cent. of its charge is lost during the 1st second."

For—

"$\frac{1}{N}$ th" read, "$\frac{1}{n}$ th"

For "potential left at end of first 2nd," read, "potential left at end of 1st second." For "potential left at end of second second will be—

$$v - \frac{v}{n} = v \text{"}$$

read, "potential left at end of 2nd section will be—

$$v - \frac{v}{n} \text{"} \qquad (1)$$

for—

$$n = \frac{V}{V v}$$

read—

$$n = \frac{V}{V - v}$$

for "therefore substituting j we get—

$$\frac{v_2}{V} = V \left(\frac{v}{V}\right)^2$$

read" therefore substituting this value in (1) it becomes

$$\frac{v_2}{V} \text{ which equals } V \left(\frac{v}{V}\right)^2$$

4th column—

for—

$$t_2 = \frac{\cdot 30103}{\log. \frac{V}{v_1}}$$

read—

$$t_2 = \frac{\cdot 30103}{\log. \frac{V}{v_1}} \cdot t_1$$

For—

$$c = \frac{t}{R \log. \frac{V}{_2 v}}$$

read—

$$C = \frac{T}{R \log.^e \frac{V}{v}}$$

ON TELEGRAPH CONSTRUCTION.

By JOHN GAVEY, Assoc. Soc. T. E.

(Continued from page 148.)

In surveying for a line along a railway, fewer difficulties are met with than on a high road. The surveyor has, as a rule, considerable latitude as to the ground he will occupy; he has no obstinate and fretful opposition from neighbouring landowners to contend with, and practically he finds himself at perfect liberty to follow whatever plan he may think most desirable. A few definite rules, however, may be laid down as of more or less general application.

The spans adopted may generally be longer than on high roads, or, in other words, fewer poles per mile are needed. The reasons are obvious, inasmuch as the curves are always more regular and gentle; and, moreover, on railways, as a rule, every pole can be stayed, so as to give the whole line a degree of stability and freedom from swaying, which on high roads is obtained by an increase in the amount of timber used. This diminution in the number of poles, which may vary from 16 to 22 or 24 per mile, does not necessarily involve a diminution in the cost of the stores, for in some cases the value of the additional stays, rods, and ratchets equals that of the timber saved. The poles on a railway should, where practicable, be placed at such a distance from the lines of metals, that in the event of their being blown down they would fall clear of passing trains. Space should also be given for staying both sides. They should, however, be always when possible, so placed that a clear view of the wires may be obtained from a railway carriage. This is of great importance in the tracing and speedy removal of faults.

In following banks and cuttings, it is preferable, whilst bearing the foregoing remarks in mind, to place the poles in such a manner that they may be as sheltered as possible from heavy winds. In precipitous cuttings however, it is occasionally advantageous to go over the top, to avoid interruptions from falling rock, &c. This is especially the case in such cuttings as have their sides almost vertical. In putting up a main line, it is generally found necessary to carry the wires over all bridges, as with the number of wires now running along each trunk line of railway, there is not room to go through any, except the most lofty ones, without danger of numerous contacts and interruptions from accidental causes. When building light lines, however, the wires may with advantage be taken through most ordinary bridges. In crossing a bridge which carries a public thoroughfare, it is the usual practice to erect two poles, one on each side of the bridge. The object is to minimise the danger of a broken wire at any time obstructing the highway.

Tunnels are an occasional source of difficulty. When wires can be carried over them it is generally done, but inasmuch as such portions are necessarily out of sight of officials travelling by train, great care should be taken to lay out and construct such lengths in the most secure and substantial manner. It however frequently becomes necessary to go through them. If the tunnels are dry and the wires not too numerous, they may be carried

hrough open on bridge brackets; but with wet unnels, or numerous wires, it is better to lay covered work. The various methods of doing this will be described in dealing with underground and covered work.

Station buildings and goods yards frequently cause some difficulties in getting through, but these are generally overcome by the use of lofty timber, and by varying the spans.

It is frequently the practice to terminate all wires in crossing over lines of rails, and whether this be done or not, it is an advantage to stay the poles on either side longitudinally or in the direction of the wires themselves. If any poles are blown down, or demolished by trucks getting off the road, the wires are thus kept from dropping across the metals, and the damage is limited in extent.

The average length of the poles used on the railways is, for heavy lines, about 28 to 30 feet, as on roads. At crossings, bridges, stations, and other localities, where necessary, the length is of course increased, the same general rules being followed as have already been dwelt upon. It is generally the practice to erect square timber on station platforms, both to provide for leading in the wire, and to harmonise with the general construction of the surrounding buildings.

In laying out the route of the poles the offsets are usefully taken from the rails when it is practicable. This saves much trouble in obtaining measurements, for, as the rails follow a more or less uniform course, the distances need not be measured at each pole, as in a road survey, but only at points where it becomes necessary to vary the offset. Surveys on railways are thus made with much greater speed and with much more ease than on roads. On viaducts the poles are generally bolted to the parapets, when these are sufficiently strong to bear the strain of the wires. For important work square timber is generally with advantage used in such cases. If properly selected and cut to the right dimensions, it resists the strain and stands better than round timber. It is also more durable, and is more easily fitted to the walls and abutments. Where but three or four wires have to be erected the expense of poles may be avoided by the use of bridge or wall brackets.

In canals and open country work, in addition to such of the points already mentioned which will be found applicable, care must be taken in crossing canals and navigable streams, either to carry the wires at such a height as will avoid interruptions from the masts and yards of sailing vessels and barges, or to carry them through by means of cables. Moreover, such localities and directions should be chosen as will admit of any of the poles being readily reached, either for inspection or for the removal of faults. A thick impenetrable underwood growth should be avoided, and when woods have to be traversed an open route practicable for horsemen should be selected. Lands liable to be flooded for considerable periods, should be avoided, and the principal consideration to be borne in mind in planning the line, should be to avoid any obstruction or impediment likely to interfere with the facile maintenance of the whole work after its completion.

ROYAL INSTITUTION OF GREAT BRITAIN.

NOTES OF PROFESSOR TYNDALL'S LECTURES ON ELECTRICITY.

FEBRUARY—MARCH, 1875.

(Concluded from page 137.)

NOTES OF LECTURE VII.

1. LORD MAHON in 1789 first observed and thoroughly investigated the "return shock." Within twenty inches of the prime conductor of his machine, he placed a second insulated conductor, and within one-tenth of an inch of the latter, a third conductor. When the machine was worked a thin stream of purple sparks passed over this small interval. On stopping the machine and discharging the prime conductor, a single brilliant spark filled the space between the second and third conductors.

2. The principles already established furnish the explanation here. By the prime conductor (charged positively) the second conductor was acted on inductively. Its negative electricity was attracted and its positive repelled. This repelled electricity produced the thin stream of purple sparks first observed. The second conductor is, therefore, to be figured as deprived in part of its positive electricity, its negative being held captive by the prime conductor. On discharging the latter, the natural condition was restored, the repelled electricity returning from the third conductor to the second in a single brilliant spark.

3. Lord Mahon fused metals, and produced strong physiological effects by the return shock.

4. In nature disastrous effects may be produced by the return shock. The earth's surface, and animals or men upon it, may be powerfully influenced by one end of an electrified cloud. Discharge may occur at the other end, possibly miles away. The restoration of the electric equilibrium by the return shock may be so violent as to cause death.

5. It was the action of the return shock upon a dead frog's limbs, observed it is said by his wife, in the laboratory of Professor Galvani, that led to Galvani's experiments on animal electricity; and led further to the discovery, by Volta, of the electricity which bears his name.

Analysis of Holtz's Electrical Machine.

6. It has been already shown in these lectures that an insulated conductor with a point attached to it may be charged, by simply presenting the point to an electrified body. This we know to be due to the streaming of the opposite electricity from the point against the electrified body.

7. If between the electrified body (charged say negatively) and the point, a plate of glass be introduced, induction will take place as before; but the positive electricity discharged from the point will cover the surface of the glass, instead of diffusing itself over the electrified body. The conductor, in this case, will be charged negatively.

8. If the glass surface thus positively electrified be removed and presented to a second point, attached to a second insulated conductor, the negative electricity will stream from the point to

neutralize the positive upon the glass. In this case the conductor, by the loss of its negative electricity through the point, will be charged positively.

9. The performance of Holtz's electrical machine is, in part, due to the action here described. The negatively electrified body is a piece of paper supported by an insulator (a stationary glass disk is employed for this purpose by Holtz). Opposite to the excited paper is placed, not a single point, but a metallic comb of points, connected with a conductor. Between the electrified paper and this comb is a glass disk capable of rapid rotation. When the paper is excited, the opposite, or positive, electricity is drawn from the comb against the glass, the conductor associated with the comb being thus charged negatively. The positive electricity is carried on by the glass and presented to a second comb placed diametrically opposite to the first. From this second comb negative electricity streams to neutralize the positive electricity of the glass, the conductor associated with the comb being charged positively. In this way two insulated conductors, connected with the two combs, can be oppositely electrified, and when the action is sufficiently strong, discharge, in the form of sparks, will pass between the conductors.

10. But this by no means fully explains the action of Holtz's machine, and to understand the explanation considerable attention will be necessary. We will approach the subject gradually.

11. First, then, we know that natural insulators are attracted by electrified bodies. An unrubbed glass rod is attracted by a rubbed one; unrubbed sealing-wax is attracted by rubbed sealing-wax. This can only occur through induction, as already explained.

12. Again, we know that when the ordinary electrophorus is excited by friction, negative electricity covers its resinous surface.

13. What we have now to add to our knowledge is this, that the layer of negative electricity with which the electrophorus is charged acts inductively upon the electrophorus itself, driving the negative of the resin to its opposite surface, and producing a positive layer between the induced and the inducing negative. The existence of the negative electricity on both sides of the resinous cake, after one side only has been excited, may be proved by the electroscope.

14. But it is only necessary to permit the cake to rest for some minutes on a metal surface connected with the earth, or for a somewhat longer time upon a common table, to abolish the negative electricity. If the cake be then turned upside down, the positive electricity of its under surface may be shown by the electroscope.

15. A disk of vulcanized india-rubber is specially suited for the rapid execution of this experiment. Whisked on one side with a fox's brush, both sides are negative. Laid with its unwhisked surface upon a table, the electricity of that surface is immediately discharged, and, on reversal, the lower surface proves to be the positive.

16. What is true of the resin cake and the india-rubber, is true of insulators generally. If one surface, for example, of a dry glass plate be electrified, it will act by induction on the rest of the plate, covering its opposite face with electricity like its own, and producing nearer to itself a layer of opposite electricity.

17. In such a plate, therefore, we have three layers of electricity, one of them communicated, and the two others inducted.

We are now, I think, prepared for the explanation of Holtz's machine.

18. Its simplest form consists of a rotating glass disk, and a fixed glass disk, on which, at the opposite ends of the same diameter, two patches of paper, provided with cardboard points, are glued. The fixed glass disk does not belong to the active part of a machine at all; it is merely employed to support the patches of paper, and to keep them insulated from each other. Out of the fixed glass disk are cut two small sectors, in which the points of cardboard freely hang.

19. Opposed to each patch of paper is placed a metal comb, the rotating disk moving between the comb and the patch of paper. Each comb is connected with an insulated brass rod bearing a knob; the two knobs being capable of being placed in contact with each other, or drawn asunder.

20. The first step towards setting the machine in action is to bring the two knobs just referred to together, and into connection with the earth. Any stray electricity lingering about the combs and knobs, which might interfere with the action of the machine, is thus got rid of.

21. Let the glass disk be set in rotation, and let an excited plate of gutta percha be brought near one of the patches of paper. It acts while there, not only on the paper, but on the metal comb immediately opposite. From that comb, against the rotating disk, is poured positive electricity, the brass rod and knob, associated with the comb, being left negatively electrified.

22. The electricity thus diffused by the comb over the surface of the glass is carried forward by the rotating disk; but here we have to remember the principle just laid down, namely, that by the inductive action of the electricity thus covering the disk, two other layers are evoked, one covering the opposite face of the disk and an opposite one within it.

23. That both surfaces of the rotating disk are here charged positively, can be proved by the electroscope. It is not a matter of theory only, but a matter of fact.

24. Let us, for the sake of distinction, call the surface of the disk turned towards the patches of paper, the inner surface, and the surface turned towards the combs, the outer surface of the rotating disk.

25. Imagine then the moving disk with both its surfaces covered, in the manner described, with positive electricity. The inner surface thus charged comes first into the neighbourhood of the cardboard point of the second patch of paper. From that point negative electricity is poured against the inner surface, neutralizing the positive of that surface. The second patch of paper is thus electrified positively, by the action of the machine itself.

26. This is a very important point to bear in mind; for, were the charge upon the patches of paper not continually renewed, the electricity would rapidly waste itself, and all action would cease.

27. But let us follow the positive electricity of the outer surface a little farther. After passing the cardboard point on the one side, it comes opposite to the metal comb on the other. Here it is

neutralized by the discharge of negative electricity from the comb; the brass rod and knob associated with the comb are thus electrified positively.

It is to be borne in mind that the body charged by a point is always furnished with the opposite electricity to that which streams from the point.

28. Let us now halt and sum up. We started from our first comb with three layers of electricity, one communicated by the comb, and the two others induced by this one. By the second cardboard point the positive induced layer was neutralized, the patch of paper associated with the cardboard point becoming, through the loss of its negative, positively electrified. A moment afterwards the positive electricity of the hinder surface was neutralized by the second comb, which poured against that surface negative electricity.

29. But over and above the quantity necessary for mere neutralization, the second metal comb, acted on inductively by the second patch of paper (now positive), poured out a still further amount of negative electricity against the surface of the disk. This also acted inductively upon the disk itself, as the positive layer did in the first instance. We have, as before, three layers of electricity; one (negative) communicated; two (positive and negative) induced; and besides these we have the negative electricity remaining over from the first act of electrification, and which was not neutralized by either the second cardboard point or the second metal comb. It is obvious from this analysis that one-half of the rotating disk must be furnished on both sides, with positive, and the other half with negative electricity.

30. The glass surface, thus negatively charged, passes on to the cardboard point of the first patch of paper (the point on both patches being turned to face the motion). Positive electricity streams from the point against the inner negative surface of the disk, the patch of paper being thus charged negatively. Immediately afterwards the negative electricity of the outer surface is neutralized by the comb, which, over and above this, is acted on by the negatively excited paper. In virtue of this action it charges the disk anew with positive electricity, which, with its two induced layers, passes on as before.

31. Thus the patches of paper, to whose inductive action the generation of the electricity is due, are continually charged by a portion of the electricity brought into play. The diffusion of the electricity in the air is thus made good, and in favourable weather the action may be prolonged indefinitely.

32. When the knobs associated with the two metal combs are drawn apart, the discharge passes between them in a stream of sparks. Connecting with the conductors (the brass rods and knobs aforesaid) a small Leyden jar, the jar is rapidly charged and discharged, the sparks being thus rendered long, loud, and brilliant.

33. The play of the electricity in Holtz's machine is perfectly obvious in the dark. The positive comb declares itself by beautiful streams of blue light darting from its points; while every point of the negative comb is tipped by a little star. The former is technically termed the "brush," and the latter the "glow."

34. Omitting all superfluous details and complications, but retaining every essential point, I have here sought to present in a compact, and easily comprehensible form, the theory of Holtz's machine developed by Riess in a series of papers extending from 1867 to 1874. An experimental examination of the machine, when in action, shows that the condition of all its parts corresponds with the theory here given.

Remark:—Two rotating and two fixed disks may be employed, instead of one. The explanation is the same. A small machine, with a single rotating disk, left to us by Dr. Bence Jones, and a larger machine, the property of Mr. Wm. Spottiswoode, were shown in action in the lecture. The former yielded sparks four inches long, the latter sparks full seven inches long.

35. The course concludes by connecting the electricity of friction and induction with other sources and forms of this power.

The contact of dissimilar metals produces electricity.

The contact of metals with liquids produces electricity (Volta).

A mere variation of the character of the contact of two bodies produces electricity (Zamboni, Behrens, and De Luc).

Chemical action produces a continuous flow of electricity (Voltaic electricity).

Heat, suitably applied to dissimilar metals, produces a continuous flow of electricity (thermo-electricity).

The heating and cooling of certain crystals produce electricity (pyro-electricity).

The motion of magnets, and of bodies carrying electric currents, produces electricity (magneto-electricity).

The friction of sand against a metal plate produces electricity.

The friction of condensed water-particles against a safety-valve, or, better still, against a box-wood nozzle through which steam is driven, produces electricity (Armstrong's hydro-electric machine).

These are different manifestations of one and the same power; and they are all evoked by an equivalent expenditure of some other power.

ON A SYSTEM OF QUADRUPLEX TELEGRAPHY.

By H. R. KEMPE.

The quadruplex system of telegraphy, by which is meant a system of sending two messages along a single wire in one direction simultaneously with two others being sent in the other direction, has been a favourite problem with telegraphists, but has hitherto had but little success, although we understand that in America a system of this kind is in use, which works well.

The primary question to be solved is that of sending two messages along the same wire in the same direction at the same time.

Such a problem, it is stated, has been solved by Stark, of Vienna; but a little consideration of his system would show that it would not answer in practice.

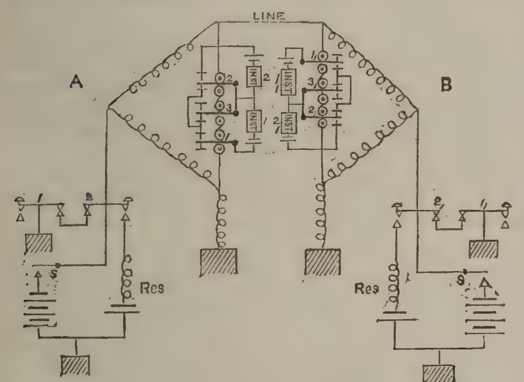
It consists of sending from the transmitting station, by two keys, currents of different intensities, the arrangement being such that on pressing one key a current of an intensity 1 is sent; on

pressing the second key, a current of an intensity 2; and on pressing both keys together, both currents are sent on the line, giving an intensity 3. The current 1 acts upon a relay sensitively adjusted, which works a recording instrument corresponding to the first key. A second relay, which is in the same circuit as the first, is unaffected by the weak current.

If the second key is pressed instead of the first a current of an intensity 2 is sent through the relays which works the second one, and thereby calls into action a local current which traverses a second set of coils wound round the first relay, but in an opposite direction to the coil through which the line current passes, the consequence being that (as stated) the first relay is unaffected. This, however cannot be the case, as before the local current can be sent through the counteracting coils of the first relay, the tongue of the second relay has to pass from the back stop to the contact stop, and during this time the tongue of the first relay will be doing the same, especially as it is adjusted to work with a weak current and will consequently very quickly respond to the stronger current.

It is true that the moment the local current is called into action the tongue of the first relay falls back to its normal position, but in the mean time a signal has been made in the recording instrument which is not wanted, and which makes the system useless. No amount of adjustment in the relays will obviate this defect.

The following system is entirely free from this objection; and, moreover, is applicable to the apparatus in common use:—



2, 3, 1 at station A and 2_1, 3_1, 1_1 at station B are ordinary relays, so adjusted as to work with strengths of current equal to 2, 3, and 1 respectively.

At each station are two keys. One being an ordinary single current key 1 and the other also a single current key 1, but of that description used for offices where the battery is in a damp situation, and which is provided with a contact spring (S) beneath the front of the lever of the key and which has a separate contact, but which is worked by the lever of the key itself.

It will be seen that when the keys are in their normal position the line is to earth through them as in the ordinary duplex arrangement, but when key 1 is pressed down the earth is taken off and the battery of power 3 is called into action, and if the key 2 be pressed down a current of an intensity 1 is sent out; and, lastly, when both keys are depressed a current of an intermediate intensity 2 is transmitted.

It is necessary, in order to effect this, that a resistance be placed in the circuit of the smaller battery, otherwise the current instead of being reduced to 2 will be less than 1.

Suppose, now, key 1 at station A is pressed down, a current of a strength 1 traverses the 3 relays at the station B, and works relay 1_1, causing the recording instrument 1_1, in connection with it, to work. Next suppose, instead of key 1, key 2 be depressed, sending out a current of strength 3; this moves all three relays, but as the current to work the recording instrument 1_1 has to traverse either the tongue of relay 3_1 or 2_1 to work it, it cannot do so in this case, as both tongues will have left these stops before the tongue of relay 1_1 will have moved over to its contact stop, but relay 2_1 will work its recording instrument 2_1.

If now key 2 is pressed, the current sinks down to strength 2, and the tongue of relay 3_1 falls back and completes the circuit for the instrument 1_1, which, consequently, now works also. If now key 1 is raised, the strength of the current increases to 3, so that the tongue of relay 3_1 moves away from its stop and opens the circuit of instrument 1_1. Again, if instead of key 1, key 2 be raised, the current sinks to 1, and the tongue of relay 2_1 falls back, leaving only the tongue of relay 1_1, over which leaves instrument 1_1 only working.

Lastly, if both keys are raised, the three tongues will be in their normal position, and, consequently, the recording instruments also.

The spare stops to relays 3, 3_1 can be used to shunt off part of the current from relays 1, 1_1 when the currents of strength 3 are passing, so that they would respond more quickly when the current ceases.

It is unnecessary to trace out the courses of the currents when the two systems are duplexed, as there are no peculiarities involved.

Owing to the difficulty of obtaining the necessary instruments, I have not been able to give the system a practical test, but the theory being apparently perfect, it may possibly be worth a trial.

ATMOSPHERIC ELECTRICITY AND OZONE.

We make the following extracts from an exceedingly interesting paper, by George M. Beard, M.D., which was read before the "American Public Health Association," in New York, Nov. 13, 1873, and has recently been published in pamphlet form:

How the subject of Atmospheric Electricity and Ozone has been Investigated. — During the past quarter of a century regular daily observations of atmospheric electricity have been made in Brussels, Munich, and for the past ten or fifteen years in St. Louis. The difficulties in the study of the subject are very great, but, from the accumulated observations of the different investigators, some few interesting and important general facts have been secured.

Ozone-History.—From the earliest recorded ages a peculiar odour has been observed during thunderstorms and other electrical disturbances, and especially in connection with flashes of lightning. The

peculiar odour of thunder-bolts has been referred to by Homer, both in the "Iliad" and the "Odyssey." Jupiter is said to strike a ship with a thunder-bolt, "ἐν δὲ θηειόυ πλητω," full of sulphurous odour, and to hurl a bolt into the ground "with the flame of burning sulphur." This peculiar sulphurous odour has been observed not only during thunder-storms, but also, it is said, during displays of northern and southern auroræ.

So long ago as 1785, Van Maurum, of Holland, observed that electric sparks passed through oxygen gas (that had been discovered by Priestley only eleven years before) gave rise to peculiar sulphurous or electrical odour; and, at the beginning of the present century, Cavallo, a prominent name in the history of electricity, called attention to the fact that this "electrified air," as it was termed, had an antiseptic effect on decomposing matter, and was a salutary application for fetid ulcers. In 1826 Dr. John Davy, in a measure anticipating Schönbein, recognized this pecularity of the atmosphere, and devised tests for detecting it.

The real scientific history of ozone dates from 1839, when Prof. Schönbein, of Basle, the renowned inventor of gun-cotton, observed that the electrolytic decomposition of water was attended by a peculiar odour resembling that evolved during the working of a frictional electric machine. In 1840 Schönbein called the attention of the scientific world to the newly discovered substance, to which he gave the name of *ozoné*, from the Greek οζειν, to emit an odour. He showed that this odour appeared at the positive pole during the electrolysis of water. He furthermore pointed out that ozone may be produced by the slow oxidation of phosphorous in moist air or oxygen, and that the odour was similar to that which is observed during flashes of lightning. Schönbein studied hard on the subject for many years, and arrived at the conclusion that oxygen is capable of division into a negatively polar state, ozone, and a positively polar state, which he called *antozone*. During the past quarter of a century the subject of ozone has been studied by some of the most eminent scientists of the age, among whom we may mention the names of Berzelius, De la Rive, Marignac, Becquerel, Faraday, Fremy, Meissner, Houzeau, Scoutteten, Odling, Andrews, Tait, Fox, Fischer, Boeckel, Zeuger, Moffatt, Nasse, Engler, Erdmann, Angus Smith, Poey, A. Mitchell, Soret, Baumert, Williamson, and very many others.

Preparation of Ozone.—Ozone is prepared in various ways—by passing electric sparks, or elctricity without sparks, through oxygen or air, by the electrolysis of acidulated water, by oxidizing phosphorus in moist air, by the action of strong sulphuric acid (three parts) on permanganate of potash (two parts), by sending water in the form of spray through air, by introducing hot glass rods into vessels filled with the vapour of ether, and by the slow oxidation of ethers and oils, &c., when exposed to light.

Properties of Ozone.—Ozone is a colourless gas, with a powerful and peculiar odour. Like oxygen, it is an oxidising agent of great power. It changes the black sulphate of lead into the white sulphate of lead. It oxidises antimony, manganese, arsenic, iron, zinc, tin, silver, lead, bismuth and mercury. Many of the lower oxides it transforms into peroxides. It corrodes india-rubber and decolorizes blue litmus-paper. It acts with great rapidity on iodide of potassium, liberating the iodine. It decomposes hydrochloric acid, liberating the chlorine. It is insoluble in acid, alkalies, alcohol, ether, the essential oils, and water. The odour of ozone is very penetrating; air containing but one-millionth of it is said to be perceptible to the smell. The peculiar odour of sea air is in part the result of ozone. All air, even the purest, has more or less ozone; but so accustomed do we become to it that it is only by sudden change into it that we perceive it. Visitors at the Mammoth Cave, Kentucky, report that, on emerging, the air has a peculiar and vivid odour, such as they never before realised. That we can in a half hour become so used to the foul air of a closed room that we do not perceive its odour until we leave it for a few moments and then return to it, is the experience of every one. The peculiar odour of ozone can be obtained very easily indeed by touching a metallic electrode of a galvanic battery of a number of cells against one of the plates of the batteries so as to make a connection of the current, or by touching the metallic ends of the poles for a moment with the spark thus produced.

Ozone in the Atmosphere.—Ozone, like electricity, exists normally in the atmosphere, but varies in amount in different localities at different seasons and in different hours of the day, and is considerably dependent on various meteorological conditions.

Average Quantity of Ozone in the Atmosphere.—The quantity of ozone in the atmosphere is exceedingly minute. The proportion varies with the locality, the season, the hour, etc., as we have already seen, and it also varies with the altitude, for it is with this agent as with electricity—it increases as we rise above the earth. According to Houzeau, air of the country, about six feet above the earth, contains about $\frac{1}{450000}$ of its weight of ozone, or $\frac{1}{700000}$ of its volume. The quantity is so minute that it may probably be increased tenfold without perceptible injury to man or animal.

Origin of Atmospheric Electricity and Ozone.—The sources of ozone in the atmosphere are almost innumerable. Like atmospheric electricity, it results from a wide variety of countless and ever-changing influences; it is one of the grand resultants of the ceaseless chemistry of the earth and sky. The evidence is now pretty clear that one prominent source of atmospheric ozone is in vegetable life. The oxygen that plants evolve from their leaves is more or less ozonized. It is claimed that ozone is developed with the perfume of flowers. The most odorous flowers, as the heliotrope, hyacinth, and mignonette, are the most prolific generators of ozone. The ozonic property of flowers is most manifest under the direct influence of sunlight. Lavender, fennel, mint, clove, and cherry-laurel evolve ozone with special abundance when exposed to the solar rays. It is believed that the oxidation of essential oils, as aniseed, bergamot, etc., under exposure to the light and air, develops ozone, and that in all flowers the source of the ozone is the essence; hence it is that the most odorous are the most ozoniferous.

We are then to look for the sources of ozone, as of electricity, in all the infinite play of terrestrial powers: in the falling away of the rocks and the

springing forth of plants; in the oxidation of metals and the emission of the perfume of flowers; in the deposition of dew, in the falling rain, the rattling hail, and the drifting snow; in the rushing of the wind and the conflict of the storm; in the friction of the clouds as they pass in the sky, or rest on the summits of the mountains; in the ceaseless evaporation on sea and on land; in the rushing torrents of the hills and the dashing breakers on the shore.

Physiological Effects of Ozone.—The physiological effects of ozone have been studied both on man and on animals. It is believed that the bracing and inspiring effect of a clear, crisp and sparkling morning is due in part to the great amount of ozone in the atmosphere. When it is held in combination with oxygen, or common air, it acts much like oxygen, but more powerfully. It affects the pulse, the respiration, and circulation in various ways, according to the quantity taken and the temperament of the individual. In this respect it behaves like electricity. It has been thought that ozone is formed in the body from the contact of oxygen gas with the blood, and there are those who believe that it is absorbed with the ozone in the air and is carried into the blood, where it takes part in the process of oxidation.

A TELEGRAPH POLE OF WROUGHT IRON.

There is now being built at the machine shop of Messrs. Townsend, Jackson & Co., in this city, an iron telegraph pole, ordered by the Western Union Telegraph Company, which is to be placed on the corner of Broadway and Twenty-third street, one of the most prominent points of observation in the City of New York. It is the invention of an Albanian, and of entirely novel construction compared with the method of making iron poles heretofore. It is the first practical invention that has ever brought such an article down to a cost sufficiently low as to compete with the use of wood, and it is claimed by the inventor that this can be done, under his patent, not only in the case of the large and costly poles used in cities, but even in the small and cheap ones used along the railroads and highways of the country.

When completed, it is lighter than a wooden pole of the same height, far stronger, and capable of supporting a much greater weight. Being of iron, it is of course more durable, and with proper care will outlast ten wooden poles. It is constructed of a number of wrought iron bars, rolled out the entire length of the pole, which bars are placed around light cast iron cores, arranged at proper intervals from each other. The cores have seats or notches to hold the bars in their places to prevent their moving sideways, and the bars also have notches into which the cores fit to keep them from moving up or down. Around the outside, where each core is placed, a ring or band of wrought iron is tightly fitted, which holds the bars firmly in their places, and thus forms the whole into a light, open and graceful column. Any number or any size of bars may be used, but it is found that six very light bars of angle iron arranged in this way afford a strength that fully meets that required for a telegraph pole of fifty feet in height. The cores are large at the base and are made smaller as they approach the top, which gives the column a graceful taper, and the whole is surmounted by a suitable cross head to hold the arms for the wires. Such a column is very simply constructed and is without a rivet throughout its entire length. No machinery or shop labour is required to put it together other than the making of the outside rings or bands by an ordinary blacksmith, so that the pole may be ordered in pieces and put together at the point where it is to stand. The column is suitable not only for telegraph poles but for masts for iron ships, derrick masts and booms, stringers for bridges, lamp posts, and a variety of other purposes.

We understand it is the intention of the Western Union Telegraph Company to introduce these poles in New York and other large cities, and we feel assured it is a move in the right direction. Iron poles have long been in use in all the cities of Europe, and this Company does not intend to allow the enterprise of our American telegraphic genius to be outrivalled or surpassed by that of any other nation. Independent of the symmetrical beauty of each pole made of this pattern, the very fact of uniformity in the construction and appearance of all the telegraph poles in a city, will take away much of the unsightliness at present complained of in regard to the wooden ones, and we are not sure but they will be more ornamental than otherwise in the streets. It is an easy matter to attach a street lamp to each pole, and thus make it serve a double purpose. It is considered by the most experienced telegraph men to be impracticable to lay the wires underground in the side streets of New York, and as soon as a scheme of rapid transit is decided upon, a suitable provision will doubtless be made in connection with it to accommodate all the wires in the city that run north and south. In the meantime iron poles are unquestionably better than wooden ones, and the use of iron lamp-posts in cities for so many years past, has proved that all things of a similar nature, that stand in the streets exposed to the public gaze, should be durable, ornamental and uniform.—*Albany Eve. Journal.*

ON THE ACTIONS PRODUCED BY THE SIMULTANEOUS MEETING OF BATTERY AND OF ELECTRO-CAPILLARY CURRENTS.

By M. BECQUEREL.

M. Becquerel inquiring if it were possible to increase or diminish the intensity of electro-capillary actions by making use of the current of a battery of several elements, used two apparatus. The first was a cracked tube containing a metallic solution, and immersed into an improuvette with an alkaline solution; the second was a pervious partition apparatus—a tube closed at bottom by a piece of parchment paper and containing a metallic solution. This latter was plunged into an eprouvette containing an alkaline solution. The electro-capillary action was increased by means of two plates of platinum in connection with a battery; the positive plate being immersed into the metallic solution and the negative plate into the alkaline. The resultant electro-chemical actions were very different according to the nature

of the solutions experimented upon. Copper and lead were reduced to the metallic state; silver, bismuth, and iron were hydrated with the alkaline; whilst gold and zinc gave no deposit. Wherefore these differences? They result undoubtedly from two existing currents, the lateral and central. The former tends to conduct metals in the metallic state to the negative surface of the pervious tissue, viz., the parchment paper, and at the same time the alkaline and the oxygen are transported to the positive plate. The elements meet on the negative surface, and the effects produced depend upon the affinities of these different substances; thus, if sulphur has a great affinity for the metal a sulphate will be produced. This takes place, as before stated, with silver, bismuth, and iron; but, if the reductive property of the current gets the better of the affinity of the metal for sulphur, a metallic reduction ensues, such as takes place with copper and lead.

STATISTICS OF IMPORTANT TELEGRAMS IN THE NETHERLANDS.

The erroneous ideas which are formed on the subject of telegraphy cannot be more advantageously met than by the aid of statistics, which are collected from data, bearing on the subject of important telegrams in the Netherlands.

Although these data only bear on the work during a period of nine months, it was thought, at the time of the meeting of the Conference of St. Petersburg, to be inexpedient to delay the publication of the results arrived at.

Months.	Total Messages:	Important Messages.	Rate %
July, 1874	120,233	1,726	14·4
August, „	118,229	1,749	14·8
September, „	117,018	1,497	18·8
October, „	117,071	1,536	13 1
November, „	111,031	1,181	10 6
December, „	105,958	1,120	10·7
January, 1875	105,118	1,779	16·9
February, „	97,654	1,600	16·4
March, „	113,831	1,601	14·0

This table shows that experience continues to be in favour of the system of important messages, receiving priority of despatch, for the number of messages of great importance is not of a scope sufficiently great to impede the free circulation of the general traffic. Moreover, as has been already shown (see *Journal Telegraphique* of January 25, 1874, No. 25), the expense necessitated by the erection and working of additional wires, would be to a great extent covered by the receipts arriving from the extra charge borne by important messages.

An analysis of the 13,789 important telegrams given in the above table, is as follows:—

Navigation	550
Press	339
Stock Exchange	10,157
Commercial Transactions ..	2,306
Private and family matters ..	377
Total ..	13,789

Of the total of 13,789 important messages, 12,350 circulated between Amsterdam and Rotterdam, and 1,433 in other directions.—*Journal Telegraphique.*

Notes.

It appears that the telegraph steamer *Faraday* was spoken on the 1st inst., in lat. 49 N., long. 43.30 W., by the steamer *Prussian*, of the Allan line, which has arrived home from Quebec. The *Faraday* had previously been engaged in laying the Direct United States Company's cable, and it was understood, on the faith of certain semi-official announcements, that her mission had been successfully completed, and that the line would shortly be opened for public traffic. We are informed, however, that, according to a report from the *Prussian*, the *Faraday* when spoken was not sailing homewards, but was engaged with the cable, which had been buoyed in two places. The report further states that there was a heavy swell at the time, that the *Faraday* was east of all ice, and that there were numerous bergs between her and the land. If the cable had a double flaw which it was necessary to repair, the delay in opening for traffic is sufficiently explained.

The estimated gross receipts of the Anglo-American Telegraph Company, at 2s. per word, average about £1,400 per day. The actual average in June, 1874, at 4s. per word, was £1,950. The receipts appear to be steadily increasing.

No further announcement has been received relative to the opening of the Direct United States Cable.

The S.S. *Caroline* has been chartered by the Post Office, and is now engaged in effecting the repairs to the Channel Islands and the Isle of Man cables, which have been interrupted for some time.

The Wheatstone Automatic is about to be adopted by the Atlantic and Pacific Telegraph Company of the United States. The Automatic continues to work with the greatest success on the French Government lines between Paris and Marseilles, where it carries an enormous amount of traffic.

The Society of Telegraph Engineers now muster 717 members of all classes, made up of—

Honorary Members	4
Foreign Members	116
Members	215
Associates	369
Students	13
Total	717

The Meyer quadruplex is working well on the Paris and Lyons line. Two instruments working from each station on the one line.

An interruption has occurred to the Scilly Isles Cable. The fault is supposed to be about 200 yards from the landing place in the Scilly Isles. During the interruption, messages are forwarded "*Via* Port Penzance."

The Submarine Company announce that all their cables are in good working order.

Professor Cornu, of the *Ecole Polytechnique*, Paris, has put into successful use a new instrument for measuring the velocity of light between two stations in which an electrical registering apparatus is used, giving, it is believed, more accurate measurements than the well-known toothed wheel arrangement of Fizian. Foucault fixed the velocity of light, by his instrument, at 185,157 miles per second; Professor Cornu, by his new instrument, fixes the velocity of light at 186,660 miles per second, or 1,503 miles faster per second than Foucault.

The communication between St. Thomas and St. Kitts has been re-established, and messages for the various West India Isles are received.

A contract for submerging a telegraph cable between Sydney (Australia) and New Zealand has been signed between the Telegraph Construction and Maintenance Company and the Eastern Extension Telegraph Company.

The number of messages passing over the Cuba Submarine Telegraph Company's lines during the month of June was 2,471, estimated to produce £2,500, against 1,874 messages, producing £2,000, in the corresponding month of last year.

The report of the Eastern Telegraph Company (Limited) shows that the revenue for the six months ended 31st March last amounted to £200,500, from which, after deducting £52,756 for ordinary expenses, £12,831 for special expenditure, and £1,111 for income-tax, there remains £133,350, which, with the balance of £1,007 brought forward, makes £134,358 net profits. The sum of £46,212 has been paid as an interim dividend, and after providing for interest on debentures, a final dividend is recommended of 2s. 6d. per share, making, with the previous distribution, 5 per cent. for the year, and leaving £35,933 to be carried to the reserve fund, increasing that fund to £150,521.

We have received the following letter from the Manager of the Direct Spanish Telegraph Company (Limited)—

"106, Cannon-street, London, July 1.

"Sir,—Several shareholders having inquired the cause of the present low quotation of this company's ordinary and preference shares, I am instructed by the board to state that they see no ground for such depreciation; on the contrary, they congratulate the shareholders on the satisfactory progress of the company's business. The accounts for the half-year ending 30th ultimo show profits sufficient to pay a dividend for the past half-year at the rate of 5 per cent. per annum on the ordinary shares, after providing all interest on preference shares up to that date. All quarterly balances up to 31st March last have been regularly received from the Spanish and French Governments. Both the company's cables continue in excellent working order.—I am, Sir, your obedient servant,

CHARLES GERHARDI, Manager.

We learn that Mr. Fuller, the Managing Director of the Brazilian Submarine Telegraph Company, and Manager and Director of the Black Sea Telegraph Company, was prevented from taking part in the conference by the sudden death of his relative, Admiral Sherard Osborne.

Two sets of Professor Wheatstone's Automatic Printing Instruments have been set up for traffic between Sydney and Melbourne.

The receipts of the Submarine Telegraph Company for the month of June amounted to £9,376 18s. 4d., against £9,186 19s. for the corresponding period of 1874.

ELECTRIC LATHE CHUCK.

In order to obviate the inconvenience and loss of time involved in the ordinary mode of fixing upon a lathe chuck certain special kinds of work, such as thin steel disks or small circular saws, the chuck is converted into a temporary magnet, so that the thin steel articles, when simply placed on the face of the chuck, are held there by the attraction of the magnet; and, when finished, can be readily detached by merely breaking the electric contact and de-magnetizing the chuck. The face plate of the magnetic chuck is composed of a central core of soft iron, surrounded by an iron tube, the two being kept apart by an intermediate brass ring; and the tube and core are each surrounded by a coil of insulated copper wire, the ends of which are connected to two brass contact rings that encircle the case containing the entire electro-magnet thus formed. These rings are grooved, and receive the ends of a pair of metal springs connected with the terminal wires of an electric battery, whereby the chuck is converted into an electro-magnet capable of holding firmly on its face the article to be turned or ground. For holding articles of larger diameter, it is found more convenient to use an ordinary face plate, simply divided into halves by a thin brass strip across the centre; a horse shoe magnet, consisting of a bent bar of soft iron, with a coil of copper wire round each leg, is fixed behind the face plate, each half of which is thus converted into one

of the poles of the magnet. The whole is enclosed in a cylindrical brass casing, and two brass contact rings fixed round this casing are insulated by a ring of ebonite, and are connected with the two terminal wires of the magnet coils. A similar arrangement is also adapted for holding work upon the bed of a planing or drilling machine, in which case the brass contact rings are dispensed with, and any desired number of pairs of the electro-magnetic face plates are combined so as to form an extended surface large enough to carry large pieces of work. For exciting the electro-magnet, any ordinary battery that will produce a continuous current of electricity can be used; but in machine shops, where power can be obtained, it is more convenient to employ a magneto-electric machine—such as Gramme's, for instance—rather than a battery.—*Scientific American.*

RAILWAY COMPANIES *v.* GOVERNMENT TELEGRAPHS.

Our contemporaries have from time to time published alarming statements of the magnitude of the claims preferred by the railway companies for the purchase of their so-called interests in telegraph business, and have declared that the Government of 1868 was left in ignorance of those claims when the Telegraphs Act was passed. It has not signified to them that the Telegraphs Act of 1868 provided for the very claims of which its promoters were supposed to be ignorant.

It has frequently been pointed out on the part of the Government that the claims of the railway companies were not to be taken as a strict measure of the sum which the companies would receive. We believe that in every case in which the Government has come to an arrangement with a railway company, either voluntarily or by arbitration, the sum taken by the company has fallen far short of that which it desired to have. In saying this we are not blaming the directors of the railway companies. It was their business to get what they could for their shareholders.

The case of the Great Eastern Railway Company has recently been under arbitration, and the award of the umpire, Mr. Russell Gurney, shows in a striking manner how wild have been the notions put forth to the public of the sums which the railway companies were likely to get. The Great Eastern Railway Company, we believe, claimed upwards of half a million of money *in meal and malt*, and also tendered a bill of costs of upwards of £12,000. It is understood that Mr. Gurney has awarded them about £77,000 in lieu of the half million, and that out of their claim for costs he has only allowed against the Post-office the sum of £3,000.

We understand that the terms which the Great Eastern Company have obtained, after a protracted struggle, are pretty much the same with those which the Post Office accorded voluntarily six years ago to the largest railway company in the kingdom, and which, while they are fair to the Government, are not illiberal to the railway shareholders.

We hope that the shareholders in those companies whose cases are still under consideration will take a warning by this result, and put no faith in the extravagant expectations which have been held out to them.

TELEGRAPHY AT ALDERSHOT.

At the summer manœuvres on Tuesday, 13th July, 1875, a line of telegraphic communication was laid down with Aldershot, and was in good working order when the staff arrived, but unfortunately there was no one at the other end to receive any communications that were sent. Every year the Royal Engineers appear to improve in the rapidity and certainty with which they perform their duty. During all the sham fights which have taken place recently, a wire has been laid in rear of both flanks of the army, and a central office opened. The desire of many officers of experience has been that the army signallers should be so posted as to be in communication with either flank or the centre of a force; and that mounted orderlies should be in atteudance at all the offices to convey at once messages to the staff. The idea is an admirable one, but has not yet been fully carried out. Generals also at present do not seem to realise the importance of telegraphic communication. For instance, last Saturday Sir John Douglas was warned over the wire that a large force was marching on his right. He relied on the cavalry for the information instead of the electric current, and the warning was received. The signallers who were out that day were charged with being incompetent, but now that a couple of days have elapsed since the action, it appears that these very intelligent men were not so much to blame as the 14th Hussars, whose advance was so tardy that the signallers never had an opportunity of getting into a position from which they could do their work, until the enemy drove them in. For them to have advanced beyond the cavalry on that occasion would only have been to ensure their capture by the attacking force. It is only just to the Royal Engineers to say that had Sir John Douglas relied upon the telegraph more than he did, he would probably have been in a much better position to resist the attack which was made upon him.

New Electro-magnetic Clock at the London Post-office.—Messrs. T. Cooke and Sons, of York, have just completed the erection of an electric motor and clock-dial in the telegraph gallery of the new buildings of the London General Post-office, St. Martin's-le-Grand, which, in some points, is novel and interesting. The hands of the large dial, which are driven by the motor, are at a distance of about forty-five feet from it, and are connected to it by means of iron rods and several pairs of bevel-wheels for turning the bends. The dial itself is six feet in diameter, and such is the sensitiveness and power of the motor that the connecting rods, bevel-wheel work, and hands, are driven by a single Leclanché cell, the current from which is transmitted to the motor every second by the standard clock in the gallery. The motor consists simply of what we may term a polarised pendulum vibrating between two pairs of electro-magnets, and carrying a double ratchet at the upper end. The same firm have erected a corresponding dial at the opposite end of the gallery for showing the direction of the wind, the pointer of which is worked by a vane at the top of the buildings.

To Correspondents.

⁎ Duly authenticated contributions, theoretical and practical, on every subject identified with the interests of which "The Telegraphic Journal" is the organ, will always command attention. Anonymous correspondence will be wholly disregarded. Literary communications and books for review should be addressed to the Editor; business communications to the Publishers, 10, Paternoster Row, E.C.

THE TELEGRAPHIC JOURNAL.

Vol. III.—No. 60.

FRANK IVES SCUDAMORE, C.B.

All telegraphists in England will learn with great regret that they are about to lose the able chieftainship of Mr. Scudamore. He has accepted an appointment in Turkey, to organise the International postal system of that country—a task for which he is pre-eminently qualified. His thirty-five years' invaluable, active, and zealous services in the Post-office have secured him a richly-deserved pension. He proceeds to Stamboul in a very short time.

Although Mr. Scudamore has been the organiser of several reforms in the Post-office, and has introduced savings bank and insurance business into the commercial *rôle* of "a nation working for itself," it will be his telegraphic enterprise which will chiefly distinguish him. Officers of the old telegraph companies will remember, when early rumours of State purchase were muttered, with what dread the name of Scudamore was received, as some monstrous ogre about to swallow them up; and how this dread was changed into affection and respect, when, on their transference to his control, they experienced his geniality, his power, his ability, and his marvellous knowledge of detail. He never had a more enthusiastic and zealous staff than that transferred to him by the commercial companies, and none will more regret the loss of his leadership than those who composed it.

There are few feats in connection with telegraphy which will be better remembered than his three days' examination in 1868 before the Committee of the House of Commons.

It is marvellous how telegraphy has thrived under his guidance. The number of offices opened to the public has increased from 2,000 to 5,600. The number of messages sent annually has leapt up from six millions to twenty millions. The average charge for inland messages has been reduced from 2s. 2d. to 1s. 2d. The number of words transmitted for the press has increased from about two millions to two hundred and twenty millions. The mileage of wire has enlarged from 49,000 to 108,000. The number of instruments has sprung from 1,900 to 11,600. Automatic and duplex telegraphy have been introduced. The pneumatic tube system has been largely extended.

Although the financial result of all this extension has not yet satisfied the money-grubbing proclivities of a certain section of the community, there can be no doubt that the public at large is highly gratified with the result of the transference of the telegraphs to the State, and if an opportunity be afforded, it will amply express its satisfaction to the author of the change. He will not depart to his new sphere of labour without receiving the warmest testimony of the confidence felt in him by his own staff, and the sincerest wishes for his prosperity, welfare, and success from all who have ever served with or under him.

THE LIFE OF CABLES.

There is a very widespread notion that the life of a submarine cable is of very limited duration, and that investment in such property is very speculative and risky. Facts in their mere historical aspect tend fully to confirm these ideas. All the earlier cables that knit our coasts with the Continent, with Ireland, and with the Channel Islands rapidly disappeared. A cable laid in 1852, and one in 1854, between Holyhead, and two in 1852 between Scotland and Ireland, were total failures. Two cables were lost between Sardinia and Africa in 1855. The first cable between Dover and Calais lasted only a day. The Crimean cable lasted but nine months. The first Atlantic cable remained entire but twenty-three days. The Channel Islands Cable of 1858 lasted three years. The Red Sea Cable of 1859 lasted only six months. On the other hand many cables which are now in existence vary from twenty years old to twenty months. The Dover and Calais, laid in 1851, and the Dover and Ostend, laid in 1853, still speak, though perhaps in the former case, little or any of the original cable remains. The England and Holland cable laid in 1858 is as sound as ever, while that laid to Hanover in the same year lasted but four years.

The existence of all these cables has been so fitful that some cause must exist to account for their irregular lives. So many cables have failed, and so many have succeeded, that sufficient facts have, however, been accumulated to justify some generalization on this point. There is no difficulty in learning lessons from the experience of the past. The materials used, the form in which these materials are fashioned into cables, the way in which they are submerged, and the localities on which they lie, have now had sufficient trial to justify some opinion as to the form of the cables of the future.

There is nothing to show that the main materials employed, whether gutta-percha or indiarubber, are destructible. On the contrary, in the case of gutta percha everything points out that it is practically indestructible. Keep it away from oxygen and from the varying conditions of temperature and climate, and it seems as though it will last for ever.

What action electric currents have upon it is not well known, but experience justifies the opinion that this action, whatever it be, is practically innocuous. In fact, gutta percha wire actually improves in insulation in our deep seas. The Suez-Aden section of the Indian cable, which lies in comparatively warm water, has improved in insulation since its submersion no less than 38 per cent., and many other deep sea cables have improved from 45 to 77 per cent. in the same quality. Gutta-percha, taken up after 25 years' submergence in water, is as perfect as when it was first put down.

But the life of a cable does not always depend upon that of its core. It rather depends upon that of its sheathing, and far more upon the bottom on which it is laid. Those cables that have failed have done so because their sheathing was not adapted to their localities. Heavy cables were laid in deep seas, light cables were laid in shallow seas, rough anchorage ground was crossed by mere pack-threads, rugged rocky bottoms and fierce tideways were spanned with slender ropes. The fact that the sheathing and structure of the cable must be adopted to the bed on which it is intended to lie is scarcely yet sufficiently followed. A cable is projected between two fixed points, a cursory examination is made of the depth of the water and of the nature of the bottom. So many miles of shore ends and so many miles of deep sea cable are specified to be used; sometimes intermediate sizes are introduced. But never has yet a cable been properly designed to meet the full requirements of its future bed. Heavy shore ends needlessly and uselessly rest upon safe and soft bottoms, light sea portions cross rocky bottoms with danger and risk. The great lessons taught by experience are these—that cables must be specially designed for the various portions of the seas they are intended to cross, and that more reliance must be placed on the careful surveys and examination of the bottom.

The durability of a cable does not depend upon the durability of its materials, but upon the special adaptability of its built-up parts to meet those great forces of nature which are present in its future home. Anchors, again, may be dropped which, when raised, strain it to its utmost limit. It is not altogether free from the attacks of insects and other assailants. Experience seems to point out fifteen years as about the average life of past cables; but if the lessons of practice have been carefully studied and followed, there is no reason why this period should not be doubled or even trebled in existing cables, and it is possible to construct, lay, and maintain cables so that they shall be practically permanent.

POST OFFICE TELEGRAPHS.

The following Parliamentary Paper has just been issued.

An Account showing the Gross Amount received during the Year ended 31st December 1874, the Amount of Expenses incurred during the year, and the Balance remaining applicable to pay the Annuities or Interest falling due upon the Securities issued under the Authority of the "Telegraph Act, 1869," and as a Sinking Fund for the Redemption of such Securities.—(Pursuant to Act 32 and 33 Vict. c. 73, s. 20.)

	£	s.	d.
Gross Amount received by the Post Office from the 1st January, 1874, to the 31st December, 1874, in respect of Telegraphic Messages, Private Wire Rentals, Special Wires, &c. ..	1,601,662	17	10
Less—Amount paid to Submarine Telegraph Companies, being Message Receipts collected on their behalf, and amount allowed to Postmasters in respect of sums paid by them for the special delivery of Messages, &c.	441,124	17	9
	£1,160,538	0	1

	£	s.	d.
Amount expended by the Post Office from 1st January, 1874, to 31st December, 1874, in respect of Salaries, Rent, Maintenance of Telegraphs, &c.	1,051,376	12	2½
Balance remaining applicable to pay the Annuities or Interest falling due upon the Securities issued under the authority of the Telegraph Act, 1869, and as a Sinking Fund for the redemption of such Securities, on the 31st December, 1874	109,161	7	10½
	£1,160,538	0	1

Notes.—1. This Account, like the previous Accounts, is based upon the actual receipts and the actual payments of the Post Office, but as Telegraph expenditure by the Office of Works was, from 1st April, 1874, borne by the Vote for that Department, the sum so paid from 1st April to 31st December, 1874, viz., £20,578, is not included in this Account.

2. During the year 1874, a proportion of the cost of providing sites for certain Post Offices was chargeable to the Telegraph Service; but as the precise proportion so chargeable has not yet been ascertained in each case, the amount has not been included in this Account. The amount is estimated at about £10 950. No provision was made in the Telegraph Vote for these charges until after the close of the year 1874.

3. In this Account is included superannuation allowances to non-effective Telegraph officers for one year and three quarters, of which about £17,800 is proper to the previous year.

Geo. Richardson, Principal Book-keeper.
General Post Office,
17th June, 1875.

Geo. Chetwynd, Receiver and Accountant General.

THE VOLTAIC BATTERY.

A Course of Six Lectures,

By Dr. JOHN HALL GLADSTONE, F.R.S.,
Fullerian Professor of Chemistry, Royal Institution.

Delivered at the Royal Institution of Great Britain.—Christmas, 1874-5.

(Continued from page 137.)

Lecture VI.—The Electric Telegraph.

It was in 1820, little more than half a century ago, that Oersted first noticed the action of the voltaic current upon a magnetic needle. I have had occasion to show you this action two or three times already, but I must show it to you again. We will take this needle, pointing at present to the north with a wire passing over it. By just making contact between the wire and a battery, we shall find that the needle will turn round. There you see the needle turning away at right angles. Now, of course, we can make and break as we please, and by sending the current the other way, the needle will turn over to the other side. So we can make it go either to the right or to the left. Now this has led to the invention of what are called galvanometers. This is the simplest form of galvanometer, but if, instead of taking a straight wire we made it coil round many times, and especially if we take what is called an astatic needle, that is, two needles which are fastened together with their poles reversed, so that the north pole of one is over the south of the other with the wire passing between, we should be able to produce movements of the needle by exceedingly feeble currents. You are aware that this has been fully carried out in Thomson's galvanometer which we have here. I explained that to you on a previous occasion, and I showed you then that there was a very small mirror suspended on the needle, and how we were able to throw a light from that moving mirror upon the screen.

See what may be done with an ordinary galvanometer. I can move the needle which way I please, or reverse it as often as I like, by the power that comes from the battery. Now, we can attach meanings to these movements of the needle. We can read one as "A" and another as "B," and so on. We might then carry the instrument to that table. I have only to make the wire longer for that purpose, or I might take the instrument up into the gallery, and do just the same as I have been doing here. But I need not be content with that, for I could take this instrument out into Albemarle-street or Piccadilly; or I might carry it to Brompton or Bayswater, and still, if there was a sufficiently long wire, the voltaic force would flow through and reach the instrument, and our needle would act in response to what took place here. Now, you see by giving certain meanings to these swingings of the needle; we can make communications at a distance to those places I have spoken of, for instance, or to Birmingham or Edinburgh, or anywhere else; and hence, we have the invention of the electric telegraph.

In the same year that Oersted noticed this movement of the needle, another great electrician, Ampére, suggested it as a means of indication at a distance. Communication by means of electricity had been suggested before that, but I believe that there was no actual electric telegraph made and used till Gauss and Weber, who were making certain observations in 1833, carried a wire from their physical cabinet to their observatory and back again—a distance of a mile—and made a needle swing, and were thus able to communicate from one place to the other. There were partially successful attempts by Ritchie and others, I believe, in this building, but we may go on to the year 1837, when Cooke and Wheatstone took out their patent for the electric telegraph, and then commenced the actual use of the electric telegraph. They employed five different needles moved by five different wires, and those needles all indicated different things, and so they were able to speak at a distance. This was employed upon the Great Western Railway, and this was the commencement of that long series of electric telegraphs which now send their metallic threads all over England and over all the civilized nations of the world. Of course, it is necessary that these wires should not touch one another, and that they should be separated from other conductors of electricity, and, therefore, they are insulated, as it is called; they are covered with thread or with something else which keeps them from other bodies. Gauss and Weber hung their wires up in the air. Cooke and Wheatstone first of all employed insulated wires, and carried them underground, but you know now very well that along our lines of railway we see the electric telegraph wires hanging in their various curves as we go along, and we cannot see, but we may imagine, if we please, the messages that are passing along those lines.

But this was only the commencement—the very infancy of telegraphy. It has since had an immense amount of attention paid to it, and an immense amount of success has attended it. Mr. Steinheil, in 1838, stretched wires in the air by insulated supports, just as we see them now arranged on poles. I do not know whether he employed the porcelain which is employed now, but there are various ways in which the wires may be suspended on the poles, so as to keep them from the damp earth. But Steinheil made another important discovery, that is to say, that it was not necessary to have two wires. It is necessary merely that you should have one wire—one wire going from your battery to your instrument, right along where you want to send the message. All that you have to do is to bring your battery in connection with the earth, and your instrument at the other end of the wire, in connection with the earth there also. Large plates are sent down into the ground to some place which is permanently damp, so that the plate may continue in connection with the earth.

Perhaps it may be difficult to explain how the earth acts; but we know that the result is a very satisfactory one. We actually get less résistance than if we employed return wires.

I must say a word about this resistance. You recollect I have spoken of different substances having very different powers of stopping the galvanic current, or, in other words, of conducting the current, and I have said that silver is that which conducts it most readily. Platinum conducts it by no means so well. Now, if we take wires of the same size throughout we find that the amount

of resistance offered by a yard would be just twice the amount of two yards. The thickness of the wire is a still more important element in it. If we have one wire twice as thick as the other, it will offer only one quarter of the resistance. The resistance is inversely as the square of the diameter of the wire. I think I may illustrate this to you in this way. I have taken here a piece of platinum wire, which is thicker in the middle than at the two sides, and upon passing the galvanic stream through it, I have little doubt that we shall be able to show you so much resistance that it becomes quite hot at the sides. [The experiment was performed.] We will increase the power. Now the middle is fairly red hot, but it is at something like a white heat at each end. So that you see that although there is not any great difference in the diameter of those two wires, the thicker one conducts very much better than the side wires, because this heating of the wire is due to the resistance offered to the galvanic stream which is passing though it. One way of explaining the action of the earth—I do not know whether it is a correct one, though—is that, although it is a very bad conductor compared with the metallic wire, it is immensely thick—of illimitable breadth, and by reason of its breadth it is unable to offer any resistance at all. However, whatever be the true explanation of this fact, we now know that it is only necessary to put a battery at one end of a wire, and an instrument at the other end, each in connection with the earth, and we get all the effect we want. And thus we may have a thousand or ten thousand messages running through the wires in different quarters, but still they are all in connection with this one great tank—the great fountain of power which is in the earth itself.

Now I should like to bring before you some of these instruments that are employed. First of all there are some which act by means of the needle which shakes in various ways. One of the simplest is this little instrument. All that is necessary to employ for this is a little chromic acid cell. This box contains the battery and the wire for communication. Here are the letters A, B, C, D, E, F, G, H, and so on, all the alphabet ranged round this dial, and numbers also, and all that I have to do when the current is on is to pass this needle round to the letter that I want to indicate, and then we shall find a corresponding movement on the little dial at the other end. You know generally upon the lines of electric telegraph they call attention by ringing the bell, so I suppose that is the proper thing for me to do in the first instance. What I have to do is to pass the handle out there, and then the bell rings, I do not know whether you can see what I am doing: I have spelt out the name of Faraday, but I am not experienced in this kind of work. The other experiments will be made by those who have had practical experience in working telegraph instruments. We will endeavour to show the same on a larger scale. We will employ one of these A, B, C instruments, and upon the large disc in front of you, you will be able to see what is spelt. You see that in that case the communication is made by wires passing all round the room. You see the festoons of wire hanging from the gallery, Mr. Hibbert is turning the machine, and he can point to any letter he likes—he seems to be taking my hint and spelling Faraday. There are a great many other ways in which messages may be sent besides that. We have upon the table some other instruments in which you can see by the shaking of needles that certain things are indicated. By Morse's arrangement, patented in 1837, by means of a succession of dots and dashes, you are able to make whatever letters you please, and we have here an instrument which works in that way. Then there is Bain's instrument, dating from 1846, which writes upon slips of paper by means of an acid solution of ferrocyanide of potassium, and forms a blue compound of iron. There is a clockwork arrangement by which the paper is passed on. You now see the blue marks upon the paper. I dare say that, after the lecture, you may like to look at that more closely, and Mr. Hibbert will have pleasure in giving you some slips of paper from that instrument. Perhaps one of you would like to write a message to be sent. If none of you will do so, I will write one.

The lecturer then wrote a message and handed it to one of the operators. The message was recorded by dots and dashes on an instrument at another part of the circuit, and read by the second operator as follows:—"Dr. Gladstone wishes you all a happy new year." The following message was then sent in the opposite direction:—"Dr. Gladstone hopes you are all pleased with his lectures."

I perfectly accept the last sentiment, though it was not one which I asked them to send on.

There are various other instruments used in telegraphing. One is in the middle there, and has a single needle. You may see how this needle instrument works—how the needle swings sometimes to one side and sometimes to the other, and sometimes several times to one side, and at other times several times to the other, so as to form a conventional alphabet of letters. This Morse's machine gives a certain clicking sound, and it was found that this sound was all that was necessary to read the message by. The receivers found that they could read by their ears what was being sent, and this fact has been employed very much in America, and it is also being employed in England, by means of what is called the Sounder. We have one of these Sounders here. I may mention that I am indebted to Mr. Johnston, of the General Post Office, and Sir Charles Wheatstone, Mr. Zimmerman, and many others, for the instruments which have been brought before you. You shall now see the Sounder in operation. [The following sentence from the printed notes of this lecture was transmitted from one instrument, and read, by means of the sound, by the operator at the second instrument:—"Besides the use of the voltaic battery for the arts of peace, it has been employed in war."]

I am sure you will accord your thanks to those gentlemen who have been giving us these illustrations.

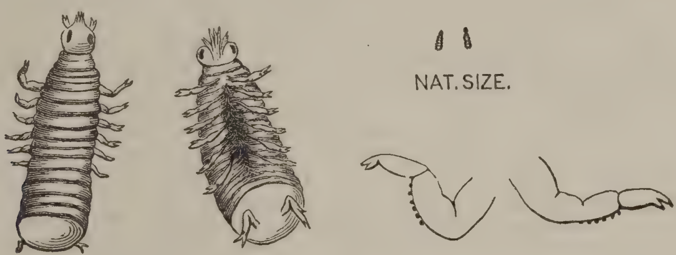
But I must say a little more about telegraphy. It is perfectly easy, of course, to put up poles, and to suspend wires on the poles, and to communicate in that way. But suppose we want to communicate across rivers, or arms of the sea, or oceans, it is quite another matter. What we have to do then is take our wire and twist round it something which keeps away the water altogether, because water has the power of carrying away the force. Several plans have been

adopted for this purpose, but the one which has generally been employed is this: First of all we take the copper wire. In this specimen there are five strands of wire — five copper wires twisted together. This is better than having one wire, for though one thick wire would conduct better than any one of these fine wires, yet still, to avoid accidents and imperfections in the wire it is better to have several.

Then you take gutta-percha, and work it up into this kind of material. It is gutta-percha cloth, and this is twisted round the wires, and thus you produce a wire with its first coating of gutta-percha. Then by putting more gutta-percha round it you got get it into this thicker form, and afterwards thicker still. [Illustrating by specimens.] Thus we have the strands of our electric cable, and we can put this, of course, across a river or across the sea, and the gutta-percha will preserve the wire from the action of the water, or insulate it, as we term it. The first attempt that was made to send a telegraph across an arm of the sea was the laying of the cable from Dover to Calais, in 1850. There were four conducting wires, and they were covered with gutta-percha. The cable spoke when shore end has to be rolled among the jagged rocks which are on the sea shore, and exposed to the billows. But when you get fairly into the deep ocean, everything goes on perfectly, and as far as we know, there are no storms of any kind whatsoever, and then we may employ a light cable such as is shown here.

I said just now there were no storms down at the bottom of the sea, but there may be dangers besides those mechanical ones. It has been found in the Irish Sea that the cable has been attacked by some little marine creature, and through the kindness of Mr. Preece I am able to show you this creature. I have got two of them in my pocket—very precious specimens indeed—and in order that you may see them I will throw them on the screen. It was found that the gutta-percha of the cable was bored into by some small animal, and of course you know what the effect would be. It would at once make a communication between the water and the inside of the cable, and then the power would turn away into the water, and we should never get a message at the other end.

A representation of one of the animals was projected upon the screen.



it was first laid, but failed after one or two days' work. The next year, however, it was laid successfully. It weighs seven tons per mile. You can easily imagine that it would not be very easy to lay a wire weighing seven tons per mile across the Atlantic. But in the great ocean there is this advantage, that the water, at any considerable depth, is very still. In 1853 a cable was laid between Dover and Ostend, and in 1858, a cable weighing only one ton per mile was laid between England and America, but this also ceased to speak almost at once. In 1865 the telegraph was laid to India, across the Persian Gulf, and it was not until the 27th of July, 1866, that there was a successful and permanent junction made between the two hemispheres of the world by means of the electric current. A battery of no very great power is required to work it. It has twelve cells of Daniell. In some of those cables which are about 2,000 miles long, by means of a Thomson's galvanometer, they are able to make communications with a very small power indeed. With two or three cells of Daniell they are able to communicate right across to America. I have here on the table a case containing specimens of the Brazilian cable. These give you the three different parts of the telegraph. This is the shore end, and it is cut across so that you may see that in the middle is the copper wire which transmits the electricity, and then there is indiarubber round it, and then various iron wires, so as to keep it in good order. Then there is more indiarubber, and after that these iron rods wound outside, so as to keep it from any mischief. This

This is a small creature of about a quarter of an inch in length, but we have magnified it with considerable power. This is the creature which eats into the cable. You see, it is made up in various segments. I do not know what the name of the animal is, but there he is before us.* Just imagine the terrible results which may be caused by this creature. One breakfast which he may take may cost more than the breakfast of any luxurious Roman epicure in ancient times, because he may destroy a whole cable, and it may take a year to repair the damage which he may do in a minute.

I think you will agree with me that no more wonderful discovery has ever been made in our own days, than this electric telegraph. I am not sure that any more wonderful invention has ever been made. It is marvellous that we are able to communicate with friends, and to send messages of affection or business across the Atlantic to our American cousins, or to India, or wherever we like, and get instantaneous replies. Think, too, of the great extension of this application of science. Think only of what takes place in the City of London, in the Central Telegraph Office, opposite the Post Office in St. Martin's-le-Grand. There stands a building which is devoted to the electric telegraph. I have taken some statistics from the *Illustrated London News*, and from these it would appear that there are in the building 500 or 600 various instruments such as we have here, and

* I have since learnt that it is a crustacean, known by the name of *Limnoria Terebrans*,

some other kinds besides, and there are about 25,000 voltaic cells. Here are some of the Post Office batteries which have been kindly brought here on purpose for our lecture. They are batteries constructed on a modification of Daniell's principle. There is a Leclanché also belonging to the Post Office. That is, I believe, actually employed for the ordinary purposes of transmitting messages, but here are some employed for more special purposes. This Leclanché battery is working this little instrument at the present time. The Leclanché batteries, as I have explained to you in speaking of them before, last a very long time without being attended to at all, so that they are extremely convenient. There are more than 500 male clerks and 740 female clerks employed at the office in St. Martin's-le-Grand, and the total number of messages sent is about 30,000 a day. As to the speed with which they may be sent, that depends upon other circumstances than merely electricity—upon the power of sending and upon the power of reading off. Sir Charles Wheatstone told me that through his automatic instrument he could send 180 words per minute. That, of course, is very rapid signalling.

(To be Continued.)

ON TELEGRAPH CONSTRUCTION.

By JOHN GAVEY, Assoc. Soc. T. E.

(Continued from page 160.)

3.—*Materials used in Construction, their properties and their selection.*

THE third branch of our subject brings us to the consideration of the materials used for Telegraph Construction; and as a knowledge of their properties, and of the points to be specially observed in their selection and application to various purposes is necessary to the Telegraph Engineer, we propose dealing somewhat fully with the more important items.

TIMBER.

Wood-producing plants are divided by naturalists into two great classes: Endogenous and Exogenous; the former growing by additions of woody matter from the interior, the latter from the exterior. An example of endogenous plants is seen in the common bamboo, and also in grasses; whilst most European trees, such as the oak, elm, pine, &c., are specimens of the exogenous class. The latter is wholly used for telegraphic purposes in this country; and this being one of the most important of the materials required in Telegraph Construction, it may be well to examine briefly its formation.

The bases of ordinary wood are substances termed cellulose and lignin, which have an almost identical chemical composition of 18C. 30H. 15O.; and the physical formation of a tree is comprised principally of cellular tissue, woody fibre, and vascular tissue. Cellular tissue appears to consist of little colourless bladders or vesicles, of various figures, adhering together in masses and filled with liquids. Woody fibre is by some considered as an elongated form of the cellular tissue, encrusted and hardened with various substances, which give the distinguishing characteristics to different classes of timber. Vascular tissue consists of small membranous spiral tubes or vessels which aerate, and possibly transmit some of the fluids in the plant.

If a transverse section of a piece of timber of the exogenous class, say pine, be examined, it will be found, beginning at the centre, to consist of,—1st, a small portion of central pith. 2ndly, the woody portion divided into the heart wood, the hardest portion of the timber; and the sap wood. 3rdly, the bark, which latter is divided into the true bark, and the epidermis; and lastly, the medullary rays, which are thin vertical plates connecting the bark and the pith, and radiating from the centre to the circumference.

If a young shoot just rising from a seed be considered, it will be found to consist primarily of the pith enclosed in a sheath called the medullary sheath, which separates it from the bark. At this early stage, the pith, which consists wholly of cellular tissue, appears to serve as a vehicle for the ascending sap, which, rising from the roots to the leaves, there comes in contact with the atmospheric air, where it combines with the elements necessary to the formation of the tree. Woody or ligneous fibre and vascular tissue, extend vertically downwards, and at the same time cellular tissue is formed horizontally. The ligneous fibres are attached to each other as it were in bundles by their respective coats, whilst the cellular tissue is forced into the thin vertical plates termed the medullary rays, which connect the pith and the bark, and are known to carpenters as the "silver grain." The residue of the sap descends through the inner bark to the roots; thus a layer of wood is gradually formed between the medullary sheath and the bark, and this action continues until the approach of winter and the fall of the leaf stops the operation.

In the spring of the following year the sap again ascends, the like processes are repeated; a second layer of wood is deposited, and so on. As each season advances towards winter the deposit takes place more and more slowly, so that well defined rings may be observed distinguishing each year's growth; the number of rings generally indicating the age of the tree in years, and the thickness of each ring, the speed or quickness of its growth. After a few years the pith dries up, and apparently serves no further purpose in the economy of the tree; and the ligneous fibres deposited nearest the centre become darkened in colour, hardened, more dense, and apparently impervious to the sap, which latter circulates upwards through the layers of woody matter last deposited; hence the distinction between the heart wood and the sap wood. This action continues year by year, the tree increasing by regular deposits of sap wood, which subsequently becomes hardened into heart wood, until maturity is reached, a period which varies with the class of the tree, and with the circumstances under which it is grown. The period of full growth, when a tree is best fitted for employment in mechanical structures is roughly indicated by the following table—

Oak - - - - -	80 to 180 years.
Ash, beech, and elm	60 to 90 ,,
Larch, spruce, and Scotch pine - - -	40 to 100 ,,

After reaching full maturity the tree begins to deteriorate, until, with the lapse of a given length of time, dependent on various circumstances, decay sets in, and the whole is again gradually resolved into its elements. With standing trees this decay

generally commences at the centre and extends thence to the circumference; so that once maturity is reached, a positive evil exisits in allowing timber to remain uncut, if intended for use in the arts. When timber has been cut and is employed in building or construction, it is exposed to different influences, and decay then assumes a different phase.

Decay or rot is known under two forms, viz.:—wet and dry rot—to both of these the presence of atmospheric air and moisture is necessary. The former appears to arise primarily from a fermentation set up by the albuminous portions of the wood, which becoming decomposed, re-act on the ligneous fibres, which in their turn are attacked; and the action appears to result in, or to be followed by, a rapid formation of the lower forms of vegetable and animal life, which draw their sustenance from, and aid in the speedy destruction of the wood. Further, when timber is exposed alternately to much moisture, then dryness, a mechanical action of disintegration, caused by the successive absorption and evaporation of moisture, appears to be called into play, and to aid in the rapid deterioration of the fibre.

Dry rot is a peculiar smouldering action whereby the whole of the tenacity of the ligneous fibres of the wood is destroyed, and the substance is reduced to powder. It is accompanied, or caused by a growth of fungus, termed Merulius Lachrymans,—even the best heart timber is occasionally rapidly destroyed, in a very few years, by this powerful agent; and this is one of the greatest enemies to the durability of wooden ships that exists.

It will be readily seen from the above considerations that, inasmuch as the sap in timber contains in itself the most ready elements of decay, it is advisable in permanent structures to employ such wood as is most free from sap, or to take special steps to eliminate this dangerous inmate. Hence, in the higher class of construction works, the wood containing the largest quantity of sap, is entirely cut away, and only the heart wood is employed; an additional reason for this precaution being that the latter is denser, tougher, and stronger than the former. It will further be obvious that, whether this course be followed or not, it will be necessary to get rid of as much of the sap which the timber holds as is possible; and for this purpose the following precautions are generally taken:—

First, the timber is felled in the winter, when the circulation of the sap is entirely stopped; secondly, in some cases, a ring is cut around the bottom of the tree through the bark and sapwood a year previous to its being felled. This cuts off the supply of sap from the ground, and that which remains in the sapwood from the previous year's growth, becoming assimilated, a large portion of that which would otherwise remain in the timber is withdrawn; and lastly, special processes are adopted either to dry up, to expel, or to neutralize the fermentative portions of the sap; and these will now be briefly described. They may conveniently be considered under two heads—

1st, *Internal Applications.*

2ndly, *External Applications.*

Internal processes are numerous, and may be classed under the following heads—

A. *Seasoning by dry air.*

B. *Neutralizing the sap* by immersion of the timber in various liquids, either with or without extra pressure.

C. *Incorporating preservative* compounds during the growth of the tree.

A. *Seasoning by dry air.* This, which is perhaps the oldest and most simple method of preparing timber for use, merely consists of stacking it in such a manner as to allow a thoroughly free circulation of the air over the whole surface, without exposing it to the direct heat of the sun or to rain. The effect is, that the more volatile portions of the sap evaporate, and the solid portions left behind do not decay so rapidly as those would that are dissipated. All timber should be well seasoned before being applied to any useful purpose, but it should be done carefully for, if exposed to the sun to hasten the process, it is apt to split and crack in all directions. A period of two years is the average duration of the seasoning operations, but even then the timber is not thoroughly dry. In fact, wood being a highly hygrometrical substance, it is impossible to dry it thoroughly in the open air. If it is desired to hasten the operation of seasoning, artificial heat is resorted to, the timber being stacked in a closed shed, and a heated current of air passed over it.

Timber invariably shrinks in drying, and this shrinkage takes place at right angles to the medullary rays; for these being rigid and, to a considerable extent, incompressible, prevent the timber from diminishing its section uniformly throughout. Hence arises the splitting and cracking which is evidenced when timber is dried.

Large timber, such as foreign pine, is frequently roughly squared by having the outer sapwood cut away. This allows the heart wood to dry more readily, and prevents the timber from splitting so much as it otherwise might.

B. *Neutralizing or washing out the sap*, by immersion in fresh or salt water, has also been applied to timber for many years. The effect is undoubtedly to dissolve, and gradually withdraw the fermentable portions of the sap from the timber, so that when the latter is used it is not liable to such rapid decay. Whilst the timber is wholly immersed, all injurious action from the sap is entirely stopped, as the quantity of water, and the almost entire absence of air are unfavourable to fermentation. The removal of the sap is hastened if running water be used; if this process of seasoning is, however, carried too far, it appears to injure the texture of the wood, diminishing its strength considerably.

Immersion under pressure in special acids and salts has of late years been very widely introduced, with varying success, according to the materials used – amongst the most successful of these may be mentioned the following — *Burnetizing*, in which chloride of zinc is the preservative agent; *Kyanizing*, where chloride of mercury is used; *Copperizing*, the agent being sulphate of copper; and *Creosoting*, the most successful of all, in which creosote is forced into the pole.

In these processes, the timber must always be thoroughly dry when it undergoes the operation. This generally takes place in strong cylindrical tanks which are fitted with hemispherical ends removable at will. To save labour, they are usually provided with a line of rails on the lower side, which communicates with tramways running throughout the creosoting yard. The poles being stacked on light trucks or trollies, are thrust into the tanks, the

ends of which being then closed, the interior is exhausted by powerful air pumps, driven by steam. The object of this is to withdraw any moisture that may remain in the wood, and also to create vacuums in the pores which may be filled by the liquid; the liquid is then allowed to flow into the tank, and is exposed to pressure varying according to circumstances. The contents of the tanks, and the quantity of the timber in them being known, the exact quantity of the salt or oil injected into the wood per cubic foot can easily be calculated. The action which takes place, and which so much retards the decay in these instances, is chemical, and it is somewhat obscure. The salts evidently combine with those elements which tend most readily to ferment, and by precipitating them, and forming new and insoluble compounds, check this tendency and lengthens the life of the timber accordingly. Creosote, in addition to the antiseptic qualities of the other salts, fills the pores of the wood with a waterproof composition, which, repelling moisture, is doubtless the cause of the immense advantage which that substance presents over all others in arresting decay.

If a transverse section of a pole treated in the above manner be examined, it will be found that the sapwood alone is permeated with the salt, the heart wood remaining untouched. Inasmuch, however, as the elements of decay are far more fully developed in the sappy portion of the timber than in the heart wood, and the latter is rarely attacked (except in a growing tree) until the former is rotten; therefore, by acting upon the sap wood so as to delay its destruction, we lengthen the life of our timber accordingly. Another method of preserving wood, termed Boucherising, which consists of injecting green timber with sulphate of copper, may be said to combine both the mechanical and the chemical forces previously referred to. Newly-cut timber, before its bark is removed, is exposed at the butt end to a slight pressure of a liquid column of sulphate of copper. The pressure forces the liquid through the longitudinal pores of the timber, till it drops out at the other extremity, both driving the sap before it, and forming the chemical combinations which effect the preservation of the wood. Poles should be exposed to the operation without the slightest delay after they are felled, or the process will probably fail, as the resinous substances rapidly harden and prevent the movement of the liquid salt through the pores. The plant needed is inconsiderable, and it can be set up in any locality, the only requirement being a clear space of open ground. This gives the system an advantage over others, like creosoting, which, intrinsically better, demand expensive and powerful machinery, and are therefore in many cases inapplicable. The arrangements in a boucherising yard may thus be described. An open tank of any convenient capacity is erected on poles at a height varying from 30 to 50 feet from the ground. From this tank descend two leaden pipes about $1\frac{1}{2}$ inches in diameter, one of which is connected with a force pump designed to fill the tank with liquid; the other serving to convey the liquid to the poles. The latter are laid side by side on racks placed horizontally, and they are arranged at right angles to a passage running the whole length of the yard. Down this passage is carried the leaden pipe from the tank, and at regular intervals of 18 inches along this pipe small branch pipes with stop cocks are fitted. As each pole is felled and hauled into the boucherising space, a section is cut off the butt end to expose a fresh uncoagulated surface of wood. Near the circumference of this newly cut surface a strip of india rubber is nailed, then a flat board somewhat larger than the base of the pole is screwed tightly against it by means of iron dogs. A hole in the centre of the board admits of the insertion of a hollow boxwood plug, which is connected with one of the small branch pipes, previously alluded to, by means of a short length of flexible indiarubber tubing. The tap being turned, the liquid solution is driven into the pole, with a pressure dependent on the height of the tank above the racks. After the lapse of a period, varying from two to twenty-four hours, the liquid makes its appearance at the top of the pole, and drops into gutters placed conveniently to catch it. The process is complete when every portion of the top of the pole is found to be saturated with sulphate of copper. This is shown to be the case when a brown stain is left on the timber by the application of a piece of potassium ferro cyanide.

Many preservative processes have been experimented with, but those above described are the most important, and of these creosoting and boucherising have perhaps been more widely employed than any others.

As a preservative for timber, creosote has hitherto borne off the palm over all other substances. Its lasting powers appear such, when properly applied, that we have not yet obtained data to show how many years a creosoted telegraph pole will last. The oil derives its antiseptic qualities from the carbolic acid which it contains.

Boucherising has hitherto given such variable and uncertain results, as render its value somewhat doubtful. It certainly increases on an average the life of the timber, to which it is applied, but whether to the full extent that it should is not yet a finally settled question. It appears open to discussion whether those poles, which have been found to fail unexpectedly, had met that careful treatment from the men conducting the operation, which is necessary for the entire success of the process. A little carelessness, in a few cases, or haste to show a large result, may sometimes bring unmerited discredit in a system intrinsically good. It is not, as a rule, successful in sand or chalky soils. Moreover, when in immediate contact with large masses of iron it is said to fail rapidly. Boucherising has been most extensively used on the Continent, and appears to meet with general favour even in localities where timber is cheap and plentiful.

C. *Incorporating preservative compounds* during the growth of a tree.

This system has been experimented on, and the possibility of incorporating certain salts with growing timber, and thereby changing its appearance, and probably its durability, has been successfully demonstrated. It has not, however, been practically applied for telegraph purposes in this country, although it is probable that a wide field for experimental research is open in this direction. The original experiments on this subject were made by Mr. Hyett, and full particulars may be seen in the Philosophical Transactions for 1846.

2. *External applications.*—These consist principally of charring, tarring, painting, and coating

with other preservative compounds. The rationale of their action is the exclusion of air and moisture, whereby the fermentation and disintegration spoken of already would to a great extent be obviated; with good sound well seasoned heart timber this has the desired effect, and witness the doors, window frames in a well appointed house, where the paint is not allowed to deteriorate, the duration is prolonged indefinitely. With telegraph poles, however, one extremity of which is always enclosed in damp soil, it is impossible to exclude moisture wholly; hence decay sets in sooner or later, and the careful maintenance of the protective coating does not insure a really long life to the wood so protected even though this wood be of a good sound quality. With young quickly grown and sappy timber the effect of this surface coating is still of less value, for not only is the wood itself from its sappy moisture more prone to decay, but it splits and cracks in all directions, and admits readily the air and moisture of the atmosphere into its interior.

It will be obvious that no attempts at external protection should be made on firm timber. If it be done, it simply results in enclosing all the elements of decay, and hastening the result which it is desired to avoid. We have had to renew larch poles which had only stood five or six years, through their having been erroneously treated in this manner. If, therefore, green or wet timber has at any time to be employed, it should be allowed to dry thoroughly before any outward application is made.

Where appearance is an object, it is customary to paint poles from the top to a point about three feet from the ground line; from this point to a depth of a foot or eighteen inches a mixture of hot gas tar, Stockholm tar, raw oil, and lime, well boiled together, is applied. This is the point at which decay develops itself most rapidly, and the one to which most attention should be given. Where appearance is no object the pole is frequently tarred throughout its length. It is an open question whether with unprepared timber this is of any use, for the upper portion of the pole will generally, without attention, last as long as the wind and water line will with all ordinary care, so that the application of tar or paint to the former appears superfluous; square timber which is free from sap wood should always be painted or otherwise protected from the weather.

It is well to char or roast over a bright fire the bottoms of all poles that are planted in their natural state (after seasoning) up to about one foot above the ground line. The pole should not be burnt, but the surface alone should be slightly charred.

The wonderful preservative effect of creosote suggests the advantage that would doubtless follow from its local outward application, when the more complete process is rendered impossible by local circumstances. Acting on this some five years ago a quantity of quickly grown open grained larch was treated as follows—

Some long ship's bilge tanks were obtained, filled with creosote, and a fire being lighted under them, the butt ends of the poles were immersed.

These were exposed to the action of the creosote for a period of eight hours, a man being kept washing over with the hot oil those portions not fully immersed. In this manner, about eight feet of the lower extremities of the poles were treated and the result appears to promise fairly, for after four years' exposure there are no signs of decay; although, from the appearance of the timber originally, there is every reason to believe that during that period the sap wood would have shewn evident signs of deterioration, had only the ordinary precautions been taken. The timber used for telegraph poles in England consists principally of the following varieties:—

1. The wild or Scotch pine (*Pinus Sylvestris*), commonly known in this country as Scotch fir. It is native to the Highlands of Scotland, but is grown in England and Wales as well; and is abundant in many parts of Europe. It forms the red and yellow deal imported from the Baltic, in which localities it reaches much larger dimensions than in Great Britain. When imported at maturity, it generally arrives in this country in rough square logs, the bark and the greater portions of the sapwood having been hewn away; hence in foreign square timber we obtain the most substantial and durable supports for telegraph wires. It is, however, much more expensive than home-grown timber; and although largely used in the early days of telegraphy, it has been to a very great extent supplanted by the latter, in all but exceptional cases. It may be said to be employed only for terminal poles, and other positions where greater strength and larger dimensions are needed, than obtained with the timber ordinarily in use. One method of applying foreign square timber at a moderate cost may, however, be glanced at as serving for light lines, in localities where the ordinary telegraph pole is unobtainable, except at a heavy freight charge. A log of timber, say 20 feet long and 13 or 14 inches square, is cut to exactly a foot square, two saw cuts are then carried down so as to divide the baulk into three planks, each four inches thick by twelve wide; these are cut transversely eight inches broad at one end and four at the other.

It will be seen that we obtain six poles, 20 feet long 8 inches by 4 at the bottom, and 4 inches by 4 at the top from a single log. These dimensions serve for light lines, and the cost per foot run does not exceed that of the cheaper forms referred to below. This system does not admit of application to long poles, as the requisite strength cannot be obtained but by use of logs of an abnormal size, which could not be readily obtained. It is now generally the practice to use young trees for telegraphic purposes with the sapwood untouched, and large quantities of young Pinus Sylvestris are annually imported for this purpose from Scandinavia. If simply seasoned before use, they would decay very rapidly, but being creosoted, a process which is generally applied to them, they become most valuable and probably exceed in durability the more costly full-grown timber, if the latter be not subjected to a like process.

Home-grown Pinus Sylvestris is likewise largely used in a round state, the bark being simply removed and the knots smoothed down. The timber is cheap, but unless special means are taken to retard decay, it rots very speedily. The supply is, however, plentiful, and it can be obtained of any required dimensions. It is generally subjected to some one of the preservative processes already described, boucherising being, perhaps, that most

generally selected on account of the portability of the plant.

2. Norway or common spruce fir (*Abies Excelsa*) is rarely used. Its principal disadvantage is its rapid decay when standing in the ground. We have had to renew poles of this class in the course of three years after their erection. But for this defect it would be useful on account of the great height and remarkable straightness with which it grows. If creosoted, it would doubtless be valuable, but its price would probably preclude its general use.

3. The common larch (*Larix Europœa*) is the most valuable timber for telegraph purposes, in its native or unprepared state, that can be employed. It is, when properly selected, hard, tough, and durable, and is in all respects an excellent material for general use. Preference should always be given to larch grown on poor, chalky, or rocky, and especially mountainous soils, as in such cases the pro ortion of sap-wood is much less than when rapidly grown in rich soil. It should be cut at from 30 to 40 years' growth, and care should be taken to ascertain that the trees show no sign of rot at the core when cut down. The poles should be felled in winter, when the sap has retreated from the wood; they should contain the natural butt of the tree, and should be free from dead knots and other imperfections. Poles with a large proportion of sap-wood should never be chosen, unless it is proposed "preparing" them with some preservative compound.

4. Pitch or red Canadian pine (*Pinus Resinosa*) is occasionally used for terminal poles, and in other analogous cases. There is but little experience of its value for telegraph purposes in England, as its price, like that of the best Baltic timber, precludes its wide-spread use.

5. Oak. This is one of the strongest and most durable of all the classes of timber employed in the arts. It is, however, too costly for general use in the form of telegraph poles, so that it is only employed in situations where great strength and lightness are needed. Thus it becomes very useful for standards fixed to permanent buildings and other similar objects, and it is largely used for the cross arms, by which insulators and wires are attached to poles.

The other classes of timber do not enter sufficiently largely into telegraph construction to make it necessary to dwell specially on them here. As a matter of course, in foreign countries, where timber differing widely from that most common in Europe is abundant, whilst the latter is scarce, it frequently becomes necessary to employ many varieties extensively. The experience that may, however, have been gained in such cases is generally confined to those directly interested, and but little is generally known in this country of the various results obtained. One of the most important points for consideration, in all materials used in structures, is their ultimate strength when exposed to stress. The ordinary strains to which they are subject tend to cause rupture, either through tearing them apart by a direct pull, by crushing, by shearing, by transverse strain, or by torsion; and it becomes necessary to ascertain the power of resistance each material opposes to either of the above forms of strain. Timber possesses much greater tensile strength, or power of resisting a direct pull in the direction of its fibres, than it does across them; the former being from 10 to 20 times greater than the latter. The following table, extracted from "Anderson's Strength of Materials," gives the force in lbs. per square inch necessary to cause rupture, both by a tensile strain, and by a crushing force; in the latter case only short pillars are referred to.

(To be continued.)

Notes.

We were indebted in our last number to *The World* for a short article on Railways and Post Office Telegraphs. *The World* is one of the most astonishing successes in the press within living memory. It owes its success not only to the startling novelty with which it deals with social questions of the day, to the fearless daring with which it exposes personal villainy, but to the smart and brilliant writing of its clever staff. It is edited by one of world-wide reputation, and personally well known to many telegraphists—Mr. Edmund Yates; and in its columns are to be seen the fine Roman hand and tuneful Dorian mood of an eminent telegraphist whose name is a household word.

Mr. Burton, Director-General of Telegraphs, conducted some highly interesting telegraphic experiments at the National Government House, Buenos Ayres, recently, in presence of President Avellaneda and a distinguished company. The chief attraction was the sending simultaneously different messages in opposite directions along the same wire. The President warmly expressed to the Director-General the great pleasure the experiments had afforded him.

The *Great Eastern* has left the old moorings in the Medway for Milford Haven, where she is going to be laid up for the present. The Telegraph Construction and Maintenance Company have not renewed the charter they had of her, which has just expired. The *Great Eastern* will always be associated with Atlantic telegraphy, to the success of which this ship mainly contributed. It is to be hoped that her services will soon again be required.

The estimated gross receipts of the Anglo-American Telegraph Company for Saturday, July 24th, at 2s. per word, amounted to £1,400, against an actual average in July, 1874, at 4s. per word, of £1,826.

The *Golos* announces the arrival at St. Petersburg of M. La Cour, assistant-director of the Copenhagen Physical Observatory, in order to submit to the telegraphic conference a new invention in telegraphy. That invention gives the possibility of transmitting despatches between two telegraphic stations through one wire only, and by means of many instruments, so that transmission by one in-

strument cannot impede the action of the other. M. La Cour, whilst engaged some years ago in investigating the passage of electric currents through conducting media, found that electricity is transmitted from place to place by undulations analagous to those of sound. In consequence of this discovery, he hit upon an arrangement of electro-magnets and tuning-forks, by means of which a particular current passing through a tuning-fork pitched to a certain note does not become merged in or confounded with other currents which, after passage through differently-pitched tuning-forks, are simultaneously transmitted along the same wire. This, of course, renders it possible to send many messages at a time through a single wire.

The report of the Globe Telegraph and Trust Company (Limited) for the year ending 18th July, gives the net revenue of the company, after deduction of expenses, as £156,539, which, with the balance brought forward, makes a total of £158,154. From this sum £2,624 has been deducted in respect of the expenses of the formation of the company, and special expenses of the proposed new issue of shares; £158,067 has been distributed in interim dividends, and a final dividend for the year of 3s. per share on the preference shares, and 2s. 6d. per share on the ordinary shares is now recommended, making, with the former distributions, a total dividend for the year of 6 per cent. upon the preference and 5 per cent. upon the ordinary shares, leaving a balance of £9,325 to be carried forward. It is mentioned that since the last report 25,437 shares of the Brazilian Submarine Telegraph Company have been exchanged for the same number of ordinary shares of the Globe Company.

The directors of Hooper's Telegraph Works (Limited) announce by circular that, owing to the absence of new contracts since the 1st January, they have decided not to pay an *ad interim* dividend for the half-year ending 30th June last. They add that negotiations are now going on for several important contracts, and one of considerable magnitude has been provisionally arranged. It is also stated that at the meeting to be held on the 20th inst. power will be sought to sanction an issue of debentures.

The Secretary of the Direct United States Cable Company (Limited) states, in explanation of complaints, "that the laying of the cable has been completed, that messages were transmitted over it at a high rate of speed between New York and London, but that a small part of the cable had been injured, probably by the ice, during the laying of the last portion of the deep sea-cable, and that the contractors were now cutting out and replacing the injured part."

At the half-yearly meeting of the Telegraph Construction and Maintenance Company, held to-day, the Chairman, Sir Daniel Gooch, Bart., M.P., stated that the contract for the cable from New Zealand to Sydney was for 1,380 miles of cable, and that it would keep the works of the Company fully occupied for the rest of the year.

The directors of the Eastern Extension Australasia and China Telegraph Company (Limited) offer for subscription an issue of £320,000 in Six per Cent. Debentures to bearer at par, repayable in 1891. The loan is rendered necessary to enable the company to provide the cable which is to connect Australia with New Zealand.

The Western and Brazilian Telegraph Company (Limited), have received telegraphic communication announcing the completion of the cable to Monte Video:—"Land lines between Brazil and Monte Video cut by revolutionists in Uruguay."

GATHERINGS FROM THE EDITOR'S NOTE BOOK.

OHM said—"The chief merit of mathematical analyses is this—it calls forth, by its never vacillating expressions, a generality of ideas which continually excites to renewed experiments, and thus leads to a more profound knowledge of nature."—"Every theory of a class of natural phenomena founded upon facts which will not admit of analytical investigation in the form of its exposition is imperfect, and no reliance is to be placed on a theory developed in ever so strict a form which is not confirmed to a sufficient extent by observation."

According to Gauss (Scientif. Memoirs, vol ii.) the moment of rotation of a bifilar magnet is proportional to the sine of deviation from the position of rest. The magnitude of the directive force of suspension depends, 1st, on the length of the suspending threads (l); 2nd., on their distance apart (d); 3rd., on the weight of the body (w), and it equals—

$$\frac{d^2 w}{l}$$

Gauss' multiplier contained 610 coils of copper wire covered with silk = 6,000 feet. It registered thermo-currents generated by the touch of the finger. It also registered frictional currents. Calladon, and subsequently Faraday, deflected needles by conveying common electricity through a wire chain in the same manner as galvanic currents. Faraday proved the minute quantity of a powerful charge. Gauss obtained the current direct from the rubber of a machine moving with a uniform velocity, and found it *sensibly uniform for all resistances.* He adds, "in our experiment, the quantity of electricity in motion depends merely on the play of the machine, and all electricity passing to the conductor in the form of sparks

must traverse the whole chain, be it long or short, in order to equalise itself with the opposite electricity from the rubber."

Harris showed that the intensity necessary to produce a spark depends solely on the density of the air, and not otherwise on the pressure or temperature. The conducting power of flame, of heated bodies, and a vacuum are due solely to the rarefaction of the air in each case.

When the proof plane is a tangent to a surface it coincides with the element which it touches; it takes in some way its plane relatively as regards electricity, or rather it becomes itself the element upon which the charge is distributed. Thus when we remove this plane we do the same thing as if we cut off from the surface an element of the same area and thickness as itself, and which we can carry to the balance without losing any of the electricity which it possesses. Once separated from the surface, this element has in its different points a density only half of that which it had, since the fluid is distributed so as to cover both surfaces of the plane symmetrically. This, however, only occurs when the plane is removed to a considerable distance from the charged conductor.

Atmospheric electricity presents examples of the commutability of physical forces; when the intensely exalted potential manifested in a flash of lightning meets with a good conductor of sufficient magnitude, that is, a body having sufficient capacity to receive and transmit the force, it is transmitted harmlessly to earth; but when that force is impressed on bad conductors, that is, on bodies *not* sufficiently capable of receiving and transmitting it, as the atmosphere and non-metallic bodies of the earth's surface, a portion of that force is converted into, or is manifested in, the form of light, heat, or dynamical force, and thus the gazing rustic is killed or blinded, the stack is fired, the oak is rent, or the tower is shivered to pieces.—*Brookes.*

EXPERIMENTS UPON THE RAPIDITY OF MAGNETISATION AND DEMAGNETISATION OF IRON AND STEEL.

By M. DEPREZ.

In prosecuting my investigations with electro-magnets and their employment in registering very rapid phenomena, I was led to enquire what was the influence of the nature of the iron in the electro-magnet upon the processes of magnetisation and demagnetisation. With this view, I employed a registering apparatus in which the pieces of iron forming the electro-magnet were movable, all the other parts, such as the coils, armature, pointer, &c., remaining the same. To measure the duration of the processes of magnetisation and demagnetisation, I employed the method described in my first communication upon electric chronographs.

The metallic portion of the electro-magnet, which I inserted successively in the magnetising coils, was formed by two cores of 2 millimetres in diameter and 13 millimetres in length. The coils, through which the current was passed, consisted of 14 metres of wire, one-fifth of a millimetre in diameter. The battery used was one Bunsen cell as modified by M. Dulaurier. The different kinds of iron tried were the ordinary iron of commerce, the specially soft telegraphic iron, malleable cast iron, grey cast iron, and, lastly, cast steel drawn and tempered.

The results obtained were entirely unexpected, for the soft iron, the ordinary iron, the malleable cast iron, and *even the tempered steel* gave, very nearly, the same results for the times of magnetisation and demagnetisation, that is to say, duration of demagnetisation, 0.00025; duration of magnetisation (approximately), 0.00150 of a second.

The grey cast iron gave still better results, for the time occupied by magnetisation was about the one-thousandth part of a second. The last-named metal is, therefore, that which would allow the greatest possible rapidity to be attained in the transmission of signals.

The final result is, that with my present registering apparatus, which will shortly be described, perfectly clear signals can be obtained, succeeding each other at intervals of one-three-hundred-and-fiftieth of a second, no matter what kind of iron is used for the electro-magnets, and at intervals of one-five-hundredth of a second when grey cast iron is employed. It should be carefully observed that I do not here speak of *signals following each other in regular succession* at intervals of a three-hundredth-and-fiftieth or five-hundredth of a second, so as to form an equi-distant series. In the latter case a number of signals much greater than 350 or 500 per second could be transmitted.

I am inclined to believe that the superiority of the cast iron is due to its molecular structure, and not to the amount of carbon contained in it. It is therefore my intention to try the *soft iron cast and not forged*, which will, I believe, give results surpassing in rapidity all that I have hitherto obtained. I propose besides in a short time to treat, in another communication, of the details of my experiments, and of the application of my registering apparatus to electric chronographs specially arranged in connection with artillery.

It should be particularly noted that the times indicated above are exclusive of the time occupied by the pointer in traversing its course. This time has to be added to that occupied by the magnetisation and demagnetisation to arrive at the three-hundred-and-fiftieth or five-hundreth of a second for the *total* duration of a signal comprising the demagnetisation, the time during which the pointer is falling, the magnetisation, and lastly, the return of the pointer to its original position. These numbers have reference besides to the case where only a single battery element is used, the number of signals per second transmitted increases with the intensity of the current.—*Association Scientifique.*

Terrible Death by Lightning. — While Nicholas Woodman, a young farmer, was riding, on Sunday afternoon last, at Haydon Bridge, Northumberland, by the side of a gig, in which were two ladies and a gentleman, a severe thunderstorm came on. Mr. Woodman was slightly in advance of the gig, when he was struck by the lightning and killed upon the spot. The horse on which he was riding was also killed, as well as the horse in the gig. The left side of Mr. Woodman was terribly burned, and his coat, vest, and watch were consumed. The occupants of the gig were not hurt.

To Correspondents.

*** Duly authenticated contributions, theoretical and practical, on every subject identified with the interests of which "The Telegraphic Journal" is the organ, will always command attention. Anonymous correspondence will be wholly disregarded. Literary communications and books for review should be addressed to the Editor; business communications to the Publishers, 10, Paternoster Row, E.C.

THE TELEGRAPHIC JOURNAL.

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THE VOLTAIC BATTERY.

A Course of Six Lectures,

By Dr. JOHN HALL GLADSTONE, F.R.S.,

Fullerian Professor of Chemistry, Royal Institution.

Delivered at the Royal Institution of Great Britain.—Christmas, 1874-5.

(Concluded from page 174.)

Lecture VI.—Practical Applications of Galvanism.

I will proceed to another application of galvanic electricity—the electric light. I have already shown you, in various ways, that sparks can be produced. If we make the terminals of our battery to consist of charcoal, then we get the spark most beautifully exhibited. The light is intensely bright. If we have copper and silver, and so on, for the terminals, they give their own particular colours to the sparks; but when we employ charcoal we get a better light than we do from anything else—a light which, in fact, rivals the sun. You see wherever the two pieces of charcoal touch we get this intensely bright light. This has nothing to do with the combustion of the charcoal; the charcoal is not burning, for the light will take place in water just as well as in the air. [The carbon terminals were immersed in a glass bowl of water, and a brilliant light was produced beneath the surface of the liquid.] The use of this light under the water has been suggested for catching fish, but I do not know with what success; perhaps the fish are enabled by it to see the net, or are led to suspect some mischief. Mr. Ladd will show you this light on the screen. The current of electricity goes from one point to the other; we suppose that it passes from the positive pole to the negative pole; we have reason for supposing that, because we find an actual transference of particles from the positive to the negative. This is the positive pole magnified on the screen, and you see the melted globules which are passing from it. It is necessary to bring the poles together at first, in order to ignite them, and then the carbon points may be removed to some distance from one another, and still this luminous vapour from the carbon flows across from one to another. You see what a beautiful band there is of this blue light starting from the white ends; we should find that the carbon would gradually wear away from one pole, and that it would be deposited upon the other. Watch these brilliant globules which are falling upon this pole; I think there is scarcely anything possible to be conceived more beautiful than that intense light, and you may imagine what force is acting there when it is capable of melting the coke. We will show you the heat of this electric light; it is, I believe, the greatest terrestrial heat we can produce; we shall be able to see upon the screen immediately the melting of metals by means of it. This electric light, as you are aware, has been suggested for various purposes; we have employed it several times during the course of these lectures, and we have been able to magnify objects and to show you phenomena which you could not otherwise have seen. But the electric light does not succeed very well for lighting up buildings. This is due to the unsteadiness of the light, especially when produced from a galvanic battery. We have now silver melting in the electric light, and this beautiful colour on the screen is caused by the vapour of silver which is passing across the interval. You see how far the vapour of silver goes; it is this green band. Now think of the heat necessary to vaporise silver; it is so beautiful that we must have another metal.

I was saying that this is not a very good light for the practical purposes of lighting buildings, for the galvanic battery is not a very constant thing, and these charcoal points have always to be kept at about the same distance, but the positive pole wears away more rapidly than the negative, and the poles are always changing their distance. This last circumstance can be overcome pretty well by machinery, but the irregularities of the galvanic battery cannot be overcome. An attempt was made to introduce this for lighthouse purposes, and Professor Faraday worked long and lovingly in order to introduce this bright light for the benefit of the sailors about our shores. But the electric light can be produced in other ways than by the galvanic battery; we can get it by rotating magnets, and by that means, originally discovered by Faraday, we are able to produce the brilliant, steady electric lights now sending their rays across the sea at Dungeness, and at two or three other places in England and France.

Here is the light due to lithium; it is caused by the magnificent vapour of that metal. Mr. Ladd is able to separate these points far from one another, because the lithium vapour conducts the voltaic force. I suppose we must look at another metal in this way.

Here is thallium. This vapour gives a peculiar green light; there it is, pouring off from the metal. You see how it is being sent out from the one charcoal, and the vapour is being condensed and deposited on the other pole.

I am very sorry that the hour is going away so fast, but I must say a word or two on another application of the voltaic force. You know very well that we can carry it to any distance we please. Well, then, we may employ it to set fire to gunpowder, or gun-cotton, or anything else of the sort, at a distance. And it has been so employed for removing obstructions in mining operations, blasting rocks, and so on. I remember one of the finest sights I ever saw was the blowing down of some of the buildings of the Great Exhibition, opposite Queen's Gate. I was then considerably interested in gun-cotton. The gun-cotton was ignited by means of the voltaic force, and the masses of building slowly settled down before us, being undermined by the blast. I have put in my pocket some string gun-cotton. You know the Austrians tried to introduce it for the purposes of war. Here is some of the Austrian match-line, and I have had a piece of it wound round there. [A piece of match-line was ignited by a battery-spark.] By just simply putting the wires upon the compound, we can set off the gun-cotton, and instead of gun-cotton we might take anything else of the same character, such as these little fuses. I do not want to blow up a large quantity of gun-

powder before you, because the fumes of gunpowder are not very pleasant, but we will ignite one of these little fuses. [An Abel's fuse was ignited by a spark from a Grove's battery.] If that fuse had been in connection with a mass of gunpowder or gun-cotton, we could have torn anything to pieces by the explosion. Well, this galvanic power, then, can be employed for a number of the arts of peace, and the more the better. Unfortunately, we have to do also with the arts of war, because the time has not yet come when nations have learnt to love one another, or when we can refer to any man, in the words of our Poet Laureate—

"As one who sings the death of war."

These batteries are employed in war for fuses and other things, and the application is especially valuable for blowing up things at a distance, and for firing torpedoes laid in channels to protect the shore. If a ship comes across one of these, we can explode the torpedo from afar, and probably make a hole in the ship.

I have now spoken to you about some of the applications of this force. We saw originally that it was a chemical force, called chemical affinity, caused by the replacement of one metal by another. We saw how this force—which was strictly chemical, consisting in the preference of one thing for another, the preference of A to combine with B, instead of with C—was able to produce phenomena which we call voltaic, and how it was capable of transferring itself to a distance; we saw also how we are able to obtain polarisation, that is, a peculiar arrangement of molecules, and the production of light and heat; and we have traced how this voltaic force is able to produce decompositions, not only in the original cell at which it starts, but other decompositions in different parts of the circuit; we have traced, too, how innumerable are the different combinations of metals, and acids, and salts which we may employ to produce this force; and how, in fact, there have been invented a very large number of batteries, each supposed to have some peculiar advantage; and during these last two lectures, or, rather, the last lecture and a half, I have endeavoured to bring before you some of the most important practical applications of this force. But before we part, I must just lead you to think how constantly this chemical force must be acting. We have it all over the world. In fact, almost all things, if they are in a wet condition, are acting upon one another. Wherever this is taking place, at any rate with three elements, we have the possibility of producing secondary chemical decompositions, and this must be constantly taking place upon the surface of the earth. You are aware, of course, that we frequently find metals in lodes in a crystalline form. We find these natural crystals assuming forms such as I showed you upon the screen artificially. Here are some specimens of silver and copper, looking very much like what may be artificially produced. Professor Tennant has kindly brought here some native copper and agates, and other things, in which we find also arborescent forms; and there is no doubt that in the formation of these minerals this chemical or voltaic force was exerted. I was at Penmaenmawr during the summer, and I got some of these specimens showing how in the slaty cleavage there this oxide of manganese assumed forms like those which we produced artificially here. In animals and plants we have this force also. I am sorry that I cannot dwell for any length of time upon this matter; but I must just show you a concluding experiment, perhaps two. The voltaic force which is produced in plants or animals is exceedingly feeble, and in order to show that there is really a galvanic battery in a plant or an animal, we must employ most delicate arrangements. With many plants, the succulent plants especially, we find that between one part and another this action is produced; and at the last Friday evening meeting in this institution it was shown by Dr. Sanderson that in the closing of Venus's Fly Trap there was a galvanic discharge. That plant has a leaf something like this—(two hands joined at the wrist, but with the palms separated, and the fingers spread)—and when the fly goes into it, it closes over the fly, and then squeezes out its juice. The fact of the galvanic current was shown us in this theatre. I have not got any of these carnivorous plants. If we take the muscles of recently killed animals we find that there is a current flowing from the inside of the muscle to the exterior part. It would be very easy to show you that my own body might form the liquid portion of a galvanic cell; but if we can show you the current in the muscle itself, then we should be showing you that which is much better. [A piece of animal muscle was placed in connection with the galvanometer.] There, our needle is swinging. It will come to rest gradually at somewhere about this point. Now you see an indication of the galvanic current in the muscle passing between the inside and the outside.

I have not been able to teach you much during these lectures. Of course, one cannot do that in six hours, but what I hope I have succeeded to a certain extent in doing is to give you an impulse to enquire further into these matters, and to make experiments for yourselves, and I do hope that you will all be students, more or less, of natural science. It is the pure study of the works of God, and, depend upon it, it will have a great effect upon your minds in enabling you to investigate truth. We are here brought right face to face with facts, and we can test our conclusions; and this does not unfit us, but, I think, fits us all the more for investigating what is true in other and, perhaps, more important branches of knowledge. Thus, I hope, you will all carry out these enquiries, and pursue these thoughts somewhat for yourselves, and if you have not much opportunity of experimenting, at any rate, read and keep your eyes open to what you may see in the rocks round about you, or other natural objects, or in the various arts of life. Let us think about the knowledge we possess, and the little observations we make, if they are true, may lead us up to the most important results, just as the little dancing of the frog's legs which Galvani observed led the way to the electric telegraph, which has extended its benefits over all the world.

I must now bring these lectures to a close. I thank you for your attention, and I hope you have had as much pleasure in listening to what I have said as I have had in speaking.

THE "SUSSEX FORTNIGHT."

The "Sussex Fortnight," as the racing period commencing with Goodwood and ending with Lewes is called,

has been of quite exceptional brilliance this year. The weather set in fine just as people were hesitating whether they would pack up for the outing which marks the close of the London season; and circumstances, generally, pointed to the probability of a very successful campaign for the lovers of the sport. Hence, the lawn and stands at Goodwood were never more numerously or brilliantly filled; better racing has seldom been witnessed in the grand old ducal park; and seldom have the general public fared so well as they did over the principal events at Goodwood, Brighton, and Lewes.

But it is not with the company, or the racing, or even with the luck of the public on these occasions that we have to do, so much as with the special telegraphic arrangements they called forth at various points in what is known as the Southern Division of the postal system. Goodwood, as many telegraphists will remember, was at no very remote period, altogether beyond the sphere of telegraphic operations. In the days of the companies the telegraph only existed at the railway station at Chichester, between which and the Grand Stand, some five miles distant, messages were conveyed by mounted messengers, at a fabulous cost both of time and money. We need hardly say that the messages were few in those days, although, few as they were, they brought in a goodly revenue by reason of the exceptionally high rates charged for their collection and transmission. In 1870 the telegraphs were transferred to the Government, and in that and the following year the business arising in connection with the Goodwood meeting was conducted at the Post Office at Chichester, where—owing to the reduction of the charge, and the increased facilities—it assumed much greater proportions than at the railway station, although it was still sadly crippled by a cumbrous and expensive messenger service. About 3,000 messages in 1870, and 4,000 in 1871, comprised the business transacted at Chichester during the Goodwood week; and perhaps the number is as large as could reasonably have been expected under the circumstances. But clearly the meeting was worth a great deal more, especially when compared with other meetings of less importance, in connection with which a wire or wires had been carried to the Grand Stand; and the Post Office was not long in suing for permission to carry its wires to the top of the Sussex Downs. Anyone who has visited Goodwood can easily understand the objection which the Duke of Richmond naturally and properly entertained against any proposition to erect poles and wires through one of the most picturesque and beautiful parks in England. An underground line would have been much too costly, especially as it would only be brought into use during a single week in the year; and it was left to the Post Office to solve the difficulty which had sorely puzzled the Telegraph Company. A flying cable very soon suggested itself; and to this project, which was carried out for the first time in 1872, the Duke of Richmond not only offered no objection, but afforded the Post Office every facility for laying out the cable, and afterwards recovering it. The cable is composed of four wires firmly bound together, and taped and tarred in the usual manner. It is about half-an-inch in diameter, or perhaps rather more, is laid out in half-mile sections, or thereabouts, and covers a total distance of nearly five miles. Starting from the main line of wires near the Drayton Station of the South Coast Railway, it threads its way—now on the top of a hedge, now at the bottom of a ditch, now under and now over the roadway, until it reaches the confines of Goodwark Park, whence it is carried among the shrubbery and through the trees to the Grand Stand. We have said that this cable was brought into use for the first time in 1872—in that and the following year it was worked from the travelling telegraph office, stationed at the Grand Stand; and on the first occasion the business of the meeting exactly doubled itself, while in 1873, the number of messages had reached 9,000, or three times as many as were disposed of at Chichester in 1870. But four circuits worked in the ordinary manner soon became inadequate for the increase of business which developed itself, immediately communication with the Grand Stand was opened up; and as there were only four wires in the cable, the adoption of Wheatstone working became inevitable. The travelling office, however, was not adapted for any extensive application of this system; and had not the Duke of Richmond supplemented his concession about the wires by a still more liberal concession in respect of an office, the development of traffic which so speedily manifested itself must have been nipped in the bud so to speak. Last year a new and commodious office, having access on three sides to the private stand, the paddock, and the public enclosure, was occupied by the Post Office; Wheatstone apparatus was brought into use on each of the four wires of the cable; and both London and Manchester were placed *en rapport* with the Sussex Downs. A most satisfactory increase of business resulted, and it was thought that the work could hardly go on increasing in the same ratio as it had done since the extension of the wires in 1872. How mistaken was this notion may be gathered from the fact that between Chichester and the Grand Stand no fewer than 13,000 messages were forwarded and received during the four days of the recent meeting, and that on a single day nearly as many messages were disposed of at the Grand Stand alone as were dealt with at Chichester during the whole meeting of 1870! Some of our readers will be able to form an idea of what working four Wheatstone circuits at full speed means, altho' the sight is hardly to be witnessed in any office out of London—but few will receive, without a certain amount of incredulity, the statement that upwards of 400 messages were received in a single batch at Goodwood without stopping, except for "paper." An average of 800 messages a-day were received for delivery at the Grand Stand, and the public enclosure was literally strewn with opened envelopes at the termination of the meeting. London, Manchester, and Newcastle were all "spoken" direct from Goodwood; press messages, of which some 1,500 were handed in for transmission during the meeting, were sent simultaneously to the two first-mentioned places, and Newcastle was "put through" in the evenings for the sporting messages, which are usually sent to the newspapers in that town. In fact, Goodwood was, for the time being, a telegraph centre of scarcely less importance than Bristol or Birmingham, and it possessed as far stretching range of communication as either of these busy centres. But within a day or so after conclusion of the meeting, the cable had been removed, and the Sussex Downs were freed once more from the trammels of civilisation for another year.

Many people wonder that the cable has never been cut, and so it is subject matter for surprise. But the arrangements for laying out and watching are very complete, and nothing worse than a cow has interfered with them. A member of this interesting species placed herself "intermediate" on the cable, by taking a bite out of it, on the day before the race meeting commenced; and thus recalled Stephenson's celebrated joke about the "coo" and the locomotive. But the "fault" was speedily detected, and as the bite could hardly have been a very savoury one, the same cow is not likely to offend again. A good deal of ingenuity is developed by the working out of such arrangements as those at Goodwood, which we have only very imperfectly described. At the recent meeting a Wheatstone weight was found wanting at the supreme moment, when the starting of a fourth transmitter was indispensable to the saving of the business from collapse. There was not even a grocer's shop within five miles at which a 56lb. weight could be borrowed, and matters threatened to turn out serious. Happy thought! A working battery is about the proper weight, and one of these attached to the chain, and hoisted into mid-air, like a veritable Mahomet's coffin, did double duty on the same circuit

during the whole of the meeting. The idea was singularly happy; for it has been one of the greatest inconveniences of the special staff, to transport the Wheatstone weights to the numerous small offices at which it has become necessary to introduce that instrument on special occasions. There is always a battery at every office, whether there is a grocer's shop in the town or not. This little circumstance, together with the rigging up of punching desks under a "spreading chestnut tree," in the postmaster's garden at Chichester, combined to impart interest and variety to a week of almost unexampled hard work at a race meeting.

We have been so interested in the arrangements at Goodwood, that we have left ourselves little space to speak of those at Brighton and Lewes. Suffice it to say, that they were not particularly striking, unless in so far as they led to an enormous increase of business at both places. The two wires at the grand stand in each case, which a year or two ago proved ample for the requirements of the respective meetings, were raised to the capacity of four by the exclusive use of the Wheatstone apparatus; and the so-called permanent offices were supplemented by a tent, in which, mounted on empty orange-boxes, or any kind of "fitting" which came handiest, the staff disposed of some 1,000 or 1,200 messages a day at each of the meetings. Altogether, the two meetings produced a total of 12,000 messages between them, as compared with 8,000 last year, and with 9,000 in 1873. We need hardly say that the effect on the telegraphic business of the district created by the annual recurrence of the "Sussex fortnight" is very much greater than can be readily inferred from the figures we have quoted above. Not only at Goodwood and Chichester, but at Bognor, Brighton, Worthing, and Southsea, as well as in the Isle of Wight, a large increase of business takes place; and it is estimated that not fewer than 29,000 telegrams must be credited to the three Sussex race gatherings. And just as Goodwood is held to mark the close of the London season, so it may be said to mark the height of the telegraphic season; for we learn that during the Goodwood week the highest number of messages on record—viz., 232,400—passed the central station, and that on two successive days of the week the numbers touched 40,000!

GRAMME'S MAGNETO-ELECTRIC MACHINES.

By ALFRED NIAUDET-BREQUET.

M. Gramme recently addressed to the Academy of Sciences a third communication respecting improvements in his magneto-electric machine. These improvements are so very remarkable that they cannot fail to be of interest to readers of the *Telegraphic Journal.**

introduced by M. Gramme are so original and so important that they constitute in themselves a work able, so to speak, to revolutionise a host of industries. We therefore give this subject prominent notice, although we may recapitulate what has already appeared in our columns.

The discovery of magneto-electric induction currents by Faraday, in 1832, opened a new field of study to physicists and inventors. Pixii, maker of scientific instruments at Paris, was the first to construct an instrument furnishing practical induction currents; his apparatus, successively improved by Saxton, Clarke, Wheatstone, Wilde, Siemens, and Ladd, has bestowed immense service upon science and industry. Singularly, this invention of Pixii is best known by the name of Clarke's machine, although Clarke, of all the persons just mentioned, introduced the least important improvement. The Nollet machine, generally known as the *Alliance*, is but a particular arrangement of a group of Clarke's instruments.

Gramme's machine is not, however, a more or less fortunate modification of Pixii's apparatus; it is the first of its kind, as the following explanation will clearly show.

Principle of the Machine.

To understand its principle it will be advisable to describe the most simple magneto-electric induction experiment which it is possible to make.

Contemplate a magnetic bar A B (Fig. 1) one metre long, and a spiral of conducting wire, in reciprocal movement. If the helix, starting from the position X, is made to approach the bar, an induced current is set up in the helix. Such is the sum and substance of the phenomenon, and there explanations as a rule stop; but let us proceed further and examine more closely what is the result in proportion as the bar enters into the helix by a series of successive and equally spaced movements—5 centimetres for example.

It will be observed that an induced current corresponds to each of these movements, and that these currents are in the same direction until the helix surrounds the neutral line M of the bar A B; and that the currents are in the opposite direction if the movement continues beyond that line.

Thus in the entire course of the helix over the magnet two definite periods are observed; in the first half of the movement the currents are *direct*, in the second they are *inverse*.

If, in place of motion from left to right, the movement is effected from right to left, the results

Fig. 1.

The *Revue Industrielle* and the *Chronique de l'Industrie* have already repeatedly referred to the admirable invention of magneto-electric continuous-current machines; but the modifications recently

are the same, but the currents are in opposite directions.

Let us now investigate a more complex case still represented by figure 1. Two magnets, A B and B' A', are placed end to end, in contact by poles of similar names, B and B'. The whole becomes a single magnet with a consequent point in the middle.

If the spiral is moved in accordance with this

* Several articles and abstracts from *Comptes Rendus*, &c., on Gramme's machines, have from time to time appeared in our pages.—Ed. T. J.

system, it is clearly seen from the preceding explanation that it is traversed by a positive current during the first quarter of its movement (between A and M); by a negative current in the second quarter (from M to B); again by a negative current in the third quarter (from B¹ to M¹); and lastly by a positive current during the last quarter of the bar (from M¹ to A¹). It will be seen hereafter how this very simple explanation gives the key to the production of currents in the machines about to be described.

DESCRIPTION OF THE APPARATUS.

The essential portion of the machine is the "ring" (Fig. 2), which turns around its centre between the poles of a magnet. It is an electro magnet of particular form. It may be conceived as a straight electro-magnet, bent into a circle and soldered together at its extremities, iron with iron, and wire with wire.

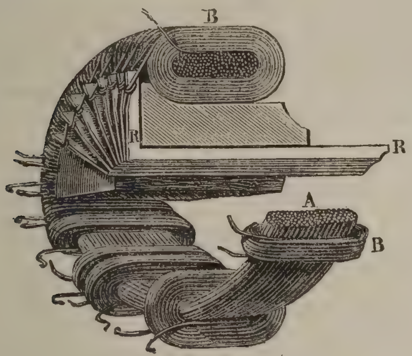


FIG. 2.

The wire is distributed upon the "ring" as in straight electro-magnets, notably those of powerful induction coils. It is rolled into distinct bobbins, which are then placed side by side, as shown in Fig. 2. These coils constitute the elements of the machine, just as voltaic couples form the elements of a voltaic battery. To render its construction intelligible, the engraving represents the "ring" complete in one part only; in another part the coils are figured by ones or twos; and in another portion the iron ring is exposed bare and cut.

This ring of soft iron is magnetised by the magnet N S (Fig 3), and the magnetism becomes distributed in the following manner. At B and A are the poles, whilst at M and M¹ (at right angles to the poles) are the neutral points. During the movement of the ring, this distribution of magnetism does not change, or at least it is invariable in position on account of the want of coercive force in soft iron. Hence, the result of turning the soft iron ring is just as if the circular iron upon which the coils are mounted was stationary, and as if these helices alone moved upon a magnetic bar.

The ring may be considered as composed of two magnets B A and A B joined by their poles of similar names. If any particular coil is followed in its movement throughout the complete circle it will be observed by referring back to fig. 1, and to the explanations already given that the developed current remains of the same character during the time the coil passes from A to M; it becomes *inverse* from M to B and from B to M¹; again changing to *direct* from M¹ to A.*

In other words, the current set up in a coil continues in the same direction from one neutral point to the other; if it is direct above that line, it is indirect below it. The line MM¹ may be called the *line of division*, and it is perpendicular to the line of the exciting magnet's pole NS. The line of division in Clarke's machine is that of the magnet's poles.

* To thoroughly understand that the direction of the current from B to M¹ is the same as from M to A, the simplest plan is to remember that the current from A to M¹ is contrary to that from B to M. This is easily perceived by again referring to "Principal of the Machine," for it is only saying that (Fig. 1) if the helix goes first from M to A and afterwards from BB¹ to M¹, the two currents thus induced are of opposite characters.

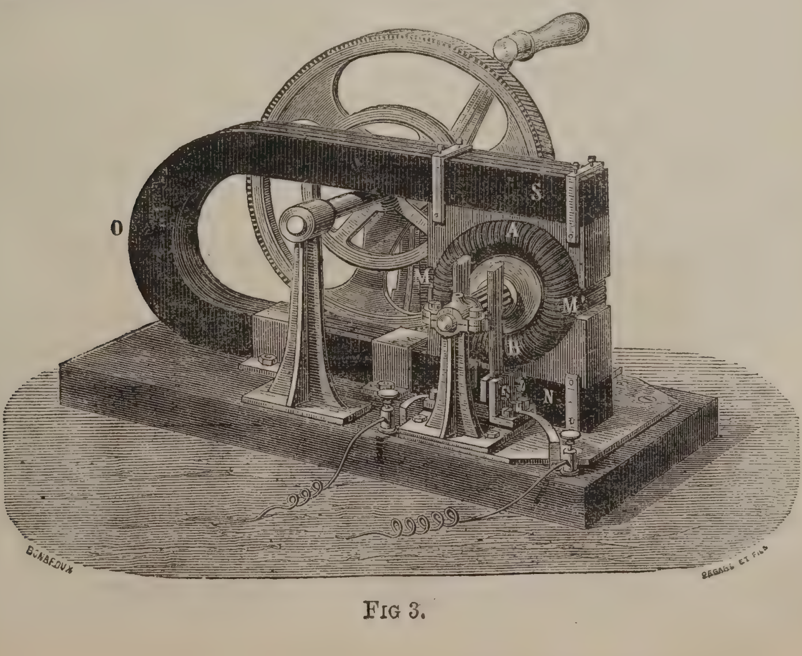


FIG 3.

Therefore we perceive, in supposing the ring to be composed of 60 coils, that the 30 coils which, at a given moment, are in the upper half-circle, are at the same time traversed by positive currents; whilst the 30 coils in the lower half of the ring are the seats of negative currents. The total current of the upper is equal to that of the lower, and the complete machine is, in all respects, comparable to a system of two batteries of 30 elements each, joined up in opposition.

Now to make use of such a system we have merely to join up the two extremities of a circuit to the ordinary poles of the two batteries when the currents are no longer in opposition, but joined up for quantity.

After this fashion M. Gramme collects the currents induced in the ring of his machine. He fixes on the line of neutral points collectors formed of copper pencils, which rub against the system of radiating pieces R (fig. 2) metallically in communication with the coils' conducting wires.

This arrangement is so novel as to require to be more fully explained. Figure 2 shows the different coils or elements of the ring and the radiating pieces R, insulated from each other, but each connected to the *exit* end of one coil, and to the *ingress* end of the following coil. These insulated pieces are bent back at right angles to the axis of the ring and are continued beyond the interior of the ring. In the complete drawing (fig 3) their extremities are noticed to be brought together into the form of a small cylinder, but insulated by burs of silk, or any other insulating material. At the same time may be seen the brushes which rub against the pieces R in a plane perpendicular to the line of the poles, *i.e.*, to the middle or neutral points M and M'.

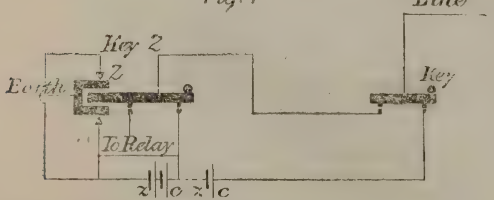
ON THE TRANSMISSION OF TWO MESSAGES IN THE SAME DIRECTION AT THE SAME TIME ON ONE WIRE.

By Mr. D. J. McGAURAN.

According to Sabine, "The first success obtained in this direction was by Stark, of Vienna, in 1855. His method consists of sending from the transmitting station by two keys two currents of different intensities, which, on arriving at the receiving station, each sets a relay in motion. The relays are arranged in such a way that when the weaker currents traverse the line only one of the relays is put in motion; when the stronger current traverses the line the other relay is affected; and lastly, when both currents go together, both the relays respond to them." I do not know to what extent Stark succeeded, but I think I will be able to show you some serious defects in the apparatus he devised, both for sending and receiving.

First, he arranges the sending keys as in Fig. 1.

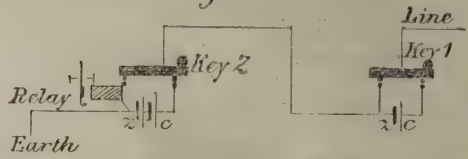
Fig. 1



* Read before the Telegraph Electrical Society of Melbourne, February 10th, 1875.

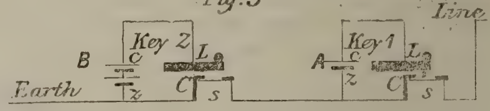
For this diagram I am indebted to Sabine. The objects attained are, that when one key is pressed down a current of a certain strength is sent, when the other key is pressed down a current of twice that strength is sent, and when both keys are pressed down a current is sent equal to both those currents combined, that is, a current of three times the strength of the current first mentioned. This proportion of the currents is not exactly true, but it is sufficiently nearly so for practical purposes. No provision is made in Stark's system for the break that takes place when, in the act of pressing either of the keys down, the lever is not resting on either the front or the back contacts. For instance, if we imagine key 2 to be closed, and transmitting a current to the distant station, the act of closing or opening key 1 will open the circuit for an instant, thus breaking the signal being transmitted by key 2. A similar effect takes place when key 2 is opened or closed while key 1 is closed, caused by the movement of the earth contact piece between the points 1 and 2. Indeed, I do not see the necessity for the complicated nature of key 2. Two keys of the ordinary construction like key 1, arranged as in Fig. 2, will accomplish all that Stark's keys effect.

Fig. 2



This arrangement is still subject to the defect before mentioned, the break caused by the opening or closing of the keys; we can get rid of this by the employment of 2 keys constructed as in Fig. 3.

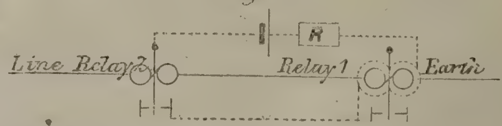
Fig. 3



When the lever L is pressed down it comes in contact with the spring S, which is immediately removed from contact with C. The battery A or B is thus put into circuit without causing any interruption.

Now let us see how far Stark's receiving apparatus will accomplish the purpose required. The diagram (Fig. 4.) is also taken from Sabine, but

Fig. 4



the local circuits for working the sounders are omitted for the sake of simplicity.

Let us imagine that the sending apparatus performs its functions perfectly—that when key 1 is pressed down a current of strength 1 is sent, when key 2 is pressed down a current of strength 2 is sent, and when both keys are pressed down at the

same time a current of strength 3 is sent. Relay 1 is adjusted so that it is moved by current 1. Relay 2 is adjusted higher, so that it requires current 2 to move it. When relay 2 moves it closes the circuit of a local battery through a coil of wire wound round the relay 1 in such a manner that the current from it neutralises the effect which current 2 would otherwise have on relay 1. A resistance coil, R, is placed in this counteracting circuit, so as to adjust the current to the proper strength. Current 3 moves both relays, because the counteracting current is only equal to current 2.

You will notice, however, that when current 2 is received, before the tongue of relay 2 can close the circuit of the counteracting battery, it has to travel from the back to the front contact, and, no matter how small a distance this may be, it takes time; moreover, relay 1 being adjusted lower moves more quickly and reaches the front stop first. The consequence is, that relay 1 closes the circuit of its sounder before the counteracting battery is put on to stop it. The result is, when key 1 alone is worked, relay 1 works all right, and relay 2 is silent; when key 2 is worked alone, relay 2 works all right, but relay 1 makes a dot every time key 2 is closed. The effect of this would be that, when both keys were forming signals, the signals made by relay 1 would be irregular and untrue, dots being made when they should not occur, &c.

The following extract from the *Telegraphic Journal*, of November 15th, 1874, will show you that the subject has been engaging attention elsewhere lately:—

"Duplex telegraphy having now been established as a system, and its great value under certain conditions having come to be generally recognised, we are not surprised to find that, in more than one quarter, efforts are being made to utilise the discovery made in 1855 by Dr. Stark, of Vienna, of sending two messages simultaneously along a wire in the same direction, and to introduce, based upon that, a system of Quadruplex Telegraphy. The American *Journal of the Telegraph* states that between New York and Boston 402 messages taken at random from the current business of the day were sent over a single wire 300 miles in one hour and a half. Four operators were employed in sending, and four in receiving. The messages were of average length, and fairly represented the ordinary correspondence of the lines. The operators were all first class, and worked as fast as they could, one of them receiving 90 messages in an hour."

If this be true, which there is no reason to doubt, the defects which I have pointed out in Stark's method must have been removed, or some new method invented. As no account of the apparatus has reached us yet, I am unable to say how the result is obtained. I have been devoting a little attention to the subject myself, but up to the present time I have not succeeded entirely to my satisfaction. It is the arrangement of the receiving apparatus that presents the greatest difficulty, the sending apparatus being comparatively simple.

There are two distinct methods by which the variation of the strength of the currents can be effected. The first is variation of the battery power; the second, variation of the resistance of the whole circuit. Increasing the resistance of course diminishes the current, and *vice versa*. Either of these methods can be used according to circumstances, but the first one is the most applicable to be used in conjunction with the *so-called* duplex system to produce the quadruplex system, and I have no doubt that the method referred to in the extract which I have just read will be found to depend on the variation of the battery power.

There are a great many modifications of both these methods. For instance, by either we can send currents varying in strength 1, 2, or 3, by one or other or both keys being pressed down; we can, by the first, send a positive current by one key, a negative current by the other, while both keys being pressed down at the same time will send a positive or negative current of twice the strength. By the second, we can vary the currents in almost any proportion we desire, according to the resistances employed.

It is by the second method that I would propose to meet the requirements of a special case which occurs in this colony. I refer to the Victorian Racing Club meetings, upon which occasions there is a large amount of business to be transmitted in one direction.

I will now describe the apparatus, which so far as I have experimented gives promise of the best result. For this particular case at the sending station (Fig. 5) there are two keys, one, key 2, of the ordinary construction, the other, key 1, being so arranged that when the lever L makes contact with the spring S it removes S from contact with P. A relay B controlling a local circuit is also placed at the sending end in case either of the receiving operators find it necessary to break. At the receiving station are shown three relays adjusted to work at different strengths of current, a key 3 for breaking, and also a main battery for supplying the current. If the line is not well insulated it would be better to place the main battery at the sending end, say, somewhere between the points A and C. However, in this particular case I anticipate no difficulty from that cause.

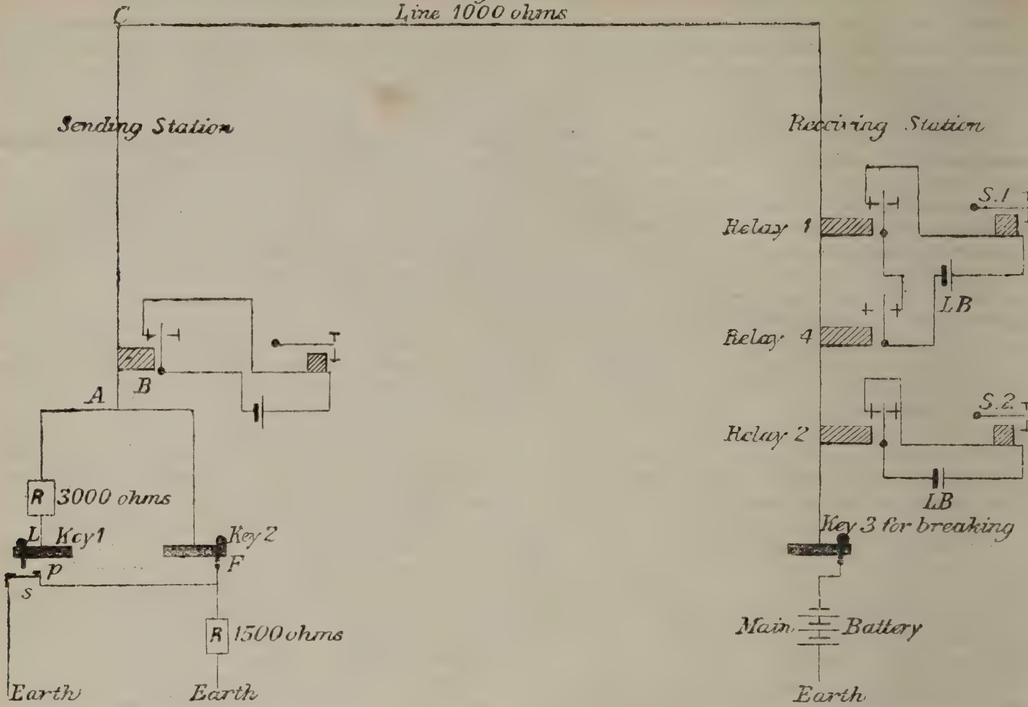
Now, let the resistance of all—apparatus, line, relays, and battery from the point A at the sending end, to the ground at the receiving end—be 1,000 ohms. Place 3,000 ohms between points A and L; place 1,500 ohms between the front stop F, of key 2, and the ground.

If key 1 is pressed down alone, the total resistance in circuit is $1,000 + 3,000 = 4,000$. If key 2 is pressed down alone, the total resistance is only 1,000, as the current has now a short circuit from A through key 2, and P S of key 1, to the ground. If both keys are pressed down at the same time, the connection between P and S is broken, and the resistance from A to the ground is now the joint resistance of 3,000 and 1,500, which is:—

$$= \frac{3,000 \times 1,500}{3,000 + 1,500} = \frac{4,500,000}{4,500} = 1,000$$

and the resistance of the whole circuit is 2,000. Therefore, when key 1 is pressed down, total resistance $= 4,000$; when key 2 is pressed down, total resistance $= 1,000$; and when both keys are pressed down, total resistance $= 2,000$; when key 1 is down, let the strength of current $= 1$; as the currents are inversely proportioned to the resistance; when key 2 is down the current is $= 4$; and when

Fig. 5.



both keys are down at the same time, the current = 2.

With these keys, then, we have perfect control over the strength of the currents, and all that now remains to be done is to arrange the receiving relays, so that they will perform their duties properly.

Each relay is marked with a number corresponding to the strength of current with which it moves. For instance, relay 1 moves with current 1, relay 2 with current 2, and relay 4 with current 4. Of course relay 1 also moves with currents 2 and 4, and relay 2 also moves with current 4.

First let us imagine both keys to be untouched. The tongues of the relays will all be lying against their back-stops; press down key 1 alone, current 1 circulates through the circuit affecting relay 1, thus closing the local circuit through the sounder S 1. Observe that this circuit passes through the tongue and back contact of relay 4. Press down key 2 alone; current 4 circulates through the circuit, affecting all three relays, relay 2 closing its local circuit through the sounder S 2, but the movement of relay 4 prevents the local circuit of sounder S 1 from being closed. Press down both keys simultaneously: current 2 circulates through the circuit; relays 1 and 2 are affected; but relay 4 remains unmoved. Consequently both local circuits now work their respective sounders.

Now, suppose while key 1 is down that key 2 is pressed down, the current is increased from 1 to 2, and relay 2 responds to the movement of key 2. If, while key 2 is down, and current 4 is circulating, key 1 is pressed down also, the current is diminished from 4 to 2, and the tongue of relay 4 closes the local circuit of the sounder S 1 by falling against the back contact. If operators are manipulating the two keys, the signals sent by key 2 are followed by the relay 2; but the signals of key 1 are followed by complicated motions of relays 1 and 4, the sounder S1 sometimes being moved by relay 1, and sometimes by relay 4. The sounder S 1 interprets, as it were, the otherwise unintelligible movements of these two relays.

I may mention that in practice I find it extremely difficult (at any rate with the relays that I have at my disposal) to regulate the adjustment so as to produce proper signals. The relays retain a considerable amount of magnetism after a current is passed through them. If current 4 is sent, relay 4 responds to it; but when this current is reduced to 2, the armature of relay 4 remains attracted instead of falling back as it ought to do. If the spring is tightened up so as to ensure the drawing of the armature back, then, if current 4 is sent, relay 1, moving more quickly, reaches the front stop before relay 4 leaves the back stop, thus causing a dot to be made on the sounder S 1.

Considerations of this sort induce me to believe that, unless relays of this construction can be procured that will work better, recourse must be had to relays constructed something like galvanometers, that is, without iron cores, and which would, of course, be free from this defect of residual magnetism. I hope to resume the subject before you at some future time, when I trust to be able to announce complete success in the matter.

Notes.

Oft-repeated wonders soon become commonplace matters. The *Faraday* which went ont to the Coast of Newfoundland in April, to complete the laying of the Direct United States Cable, has just returned,

entered the Thames, taken in a stock of fresh cable, started on her return journey to complete her task, and no mention has been made of her in the morning papers! She had laid the cable, and it worked well, but there was a fault 250 miles off Newfoundland, which it was thought better to cut out, and she came home for more cable to enable her to do so.

It is narrated that certain Chinese fishermen brought up to the surface a submarine cable; that they cut it in small pieces, and planted it, hoping it would grow.

The traffic receipts of the Direct Spanish Telegraph Company for the month of July, 1875, were £1,834, against £1,349 in the corresponding period of last year.

The average time occupied in the transmission of telegrams between Madrid and England, "*via* Santander," was 3 hours and 9 minutes (including transmission over Spanish land lines).

An important case has been tried in the Vice-Admiralty Court of the Dominion of Canada, whereby the owners of a large timber ship, the *Czar*, have been condemned in costs and damages for injury done to a submarine cable crossing the river St. Lawrence, near Quebec, through the negligence of the persons in charge of her allowing her to drag her anchor over the cable.

Special events appear as prolific of telegraphic business in the United States as in England. Saratoga regatta produced 113,446 words of press matter, and 4,270 private messages. An office was opened at the Grand Stand, which was connected by a quadruplex with New York.

The Indiarubber, Gutta-percha, and Telegraph Works Company (Limited) have received news by telegraph of the successful laying and completion of their cable between Callao and Islay, in Peru. This section, about 460 miles in length, is the first of a series of cables, with stations at Arica and Iquique, in Peru, and Caldera in Chili, which will place those ports, as well as Lima and Valparaiso, in telegraphic communication with Europe—first by the Transandine wires and the Brazilian cable system, and ultimately by the Isthmus of Panama, when a cable shall have been laid thence to Callao.

Mr. Stearns has successfully introduced duplex working into France. The system he has inaugurated is capable of six combinations, viz., Morse single working, Hughes single working, Morse duplex, Hughes duplex, Morse-Hughes duplex, Hughes-Morse duplex. The bridge system is used, and the results upon the Hughes are very satisfactory, because it is found that the instruments work better duplexed than on the ordinary single method, from the fact that the outgoing currents do not pass through the home instruments, and therefore disturb them. Paris has been working to Havre uninterruptedly since the commencement of the year.

DECAY OF TIMBER.

THE following interesting description of a great enemy to all telegraphists is taken from a charming work by the Rev. Hugh MacMillian, on the "First Forms of Vegetation." Evidence of the presence of fungi is to be found in nearly every rotten pole, but whether the fungus is the cause or consequence of the decay is a vexed question. That it is so in some cases of *dry rot* is quite certain, but that it is so in *wet rot* is uncertain. Our readers—especially those who possess microscopes, that "new sense," —would do good service to science if they would investigate every case of incipient decay with a view of solving this question.

"It is not only in food and luxuries that man suffers from the ravages of fungi; he also suffers in his property. Builders have painful knowledge of one or two species, known under the common name of dry-rot. This most destructive plague is usually caused in this country by the *merulius lachrymans*. It occurs on the inside of wainscoting, in the hollow trunks of trees, in the timber of ships, and in the floors and beams of buildings in moist, warm situations, where there is not a free circulation of air. It appears at first in round, white, cottony patches, from one to eight inches broad, which afterwards develope over their whole surface a number of fine yellow, orange, or reddish-brown irregular folds, most frequently so arranged as to have the appearance of pores, and distilling drops of moisture when perfect; whence its specific name. In the mature state it produces an immense number of minute rusty sporules, which alight and speedily vegetate in the circumjacent timber, destroying its elasticity and toughness, and rendering it incapable of resisting any pressure, until gradually it crumbles into dry brown dust. This insidious disease, once established, spreads with amazing rapidity, destroying some of the best and most solid-looking houses in a few years. The ships in the Crimea suffered more from this cause than from the ravages of fire, or the shot and shells of the enemy. The dry-rot of oak-built vessels is caused, however, not by the merulius but by the *polyporus hybridus*, whose mycelium forms a dense membrane of branched creeping strings, while the pores of the hymenium are long, slender and minute. So virulent is the nature of dry-rot that it extends from the woodwork of a house even to the walls themselves, and by penetrating their interstices, crumbles them into pieces. We have every reason to believe that the leprosy of houses, so graphically described in Leviticus, was a dry-rot caused by some species of merulius or polyporus; the materials and sanitary condition of Eastern houses being peculiarly favourable for the development and spread of fungous growth. "I knew," says Professor Burnett, "a house into which the rot gained admittance, and which, during the four years we rented it, had the parlours twice wainscoted, and

a new flight of stairs, the dry-rot having rendered it unsafe to go from the ground-floor to the bedrooms. Every precaution was taken to remove the decaying timbers when the new work was done; yet the dry-rot so rapidly gained strength that the house was ultimately pulled down. Some of my books which suffered least, and which I still retain, bear mournful impressions of its ruthless hand: others were so much affected that the leaves resembled tinder, and when the volumes were opened, fell out in dust or fragments.

Many practical persons have written upon this disease, and the remedies proposed are as numerous as their authors. But the only certain preventives of the evil seem to be the removal of the decaying and contagious matter, the kyanizing or impregnating of the surrounding wood with a strong solution of corrosive sublimate or coal-tar, and the admission of a free current of air. Much also may be done by cutting timber destined for building purposes in winter, when fungi are usually dormant or dead, and properly seasoning it by steeping it before it is used. Houses, in order to be free from this plague should be built in dry, open, and airy situations, and efficiently ventilated throughout every part, especially of the wood work. When these conditions are observed, this evil will disappear."

GATHERINGS FROM THE EDITOR'S NOTE BOOK.

Mr. Stuart Wortley, when Chairman of the Atlantic Telegraph Company, said that while they anticipated obtaining only 5 or 6 words per minute through the cable, they succeeded in getting, by means of Thomson's reflecting galvanometers, 15, and sometimes 20 words per minute.

Dr. W. H. Russell wrote in 1865:—

"But as a mite would in all probability never have been seen but for the invention of cheese, so it may be that there is some undeveloped creation waiting, *perdu*, for the first piece of gutta-percha, which comes down to arouse his faculty and fulfil his functions of life—a gutta-percha boring and eating *teredo*, who has been waiting for his meal since the beginning of the world." He may be ranked as a prophet, for the borer has appeared in the *limnoria terebraus.*

In order to try the porosity of pure gutta-percha, Macintosh, put upon the inner core some chemical substance, which upon contact with water changed colour. This was then covered with gutta-percha, and subjected to hydraulic pressure. Water in every case penetrated to the core under a pressure of 2 tons to the square inch.

Sir W. Thomson calls the British statute mile "that most meaningless of modern measures," and invariably means by mile the nautical mile, or the length of a minute of latitude in mean latitudes = 6,073 feet. For approximate measurement it may be taken as 6,000 feet or 1,000 fathoms. He calls the sea the very safest place in which a submarine cable can be kept, and asserts that sea water is the best preservative of gutta-percha. No case of decay of gutta-percha in water has ever been known.

The 1866 Atlantic Cable, when tested at the Gutta Percha Works, at 75° Fahr. gave a mean resistance of 374 ohms per knot (after 1 min. electrification) after being submerged the resistance of whole cable (1854 miles) was 1·316 ohms or 2437 ohms per knot. Temperature of water about 40° Fahr. Pressure at deepest point (about 2,400 fathoms) about 6,418 lbs. (nearly 3 tons) per square inch. Cable took 66 minutes to fall from charge to ½ charge. The resistance of copper conductor was 7202 ohms or 3·88 per knot.

Mr. Latimer Clark, telegraphed through both Atlantic Telegraph Cables with a battery formed in a lady's thimble, and Mr. Collett said, "I have just sent my compliments to Dr. Gould of Cambridge, who is at Valentia, with a battery composed of a gun cap with a strip of zinc excited by a drop of water, the simple bulk of a tear."

The following table may be regarded as a fair indication of the rate at which cables of the average inductive capacity can be worked with the mirror:

NUMBER OF WORDS PER MINUTE.

Weight of copper strands, lbs.	Knots, 1,000.	Knots, 1,500.	Knots, 2,000.	Knots, 2,500.
100	18·3	8·1	4·6	2·9
150	27·5	12·2	6·9	4·4
200	37·0	16·4	9·2	5·9
250	46·0	20·4	11·2	7·4
300	55·0	24·4	14·0	8·8
350	64·1	28·5	16·0	10·3
400	73·2	32·5	18·3	11·7

Cyrus Field said, when the 1865 cable failed, "Let us not despair, I have seen worse disasters than this in Atlantic telegraphy, and I know we must eventually succeed."

One man said, "I have put into the enterprise my all, but with God's blessing I shall live to see the Atlantic Cable laid. In spite of what has occurred, I am more than ever satisfied of the practicability of laying it."

When the Great Eastern arrived at Heart's Content "a blind girl, led by her young brother, walked about the deck, and gathered, from his intelligent description and by the exercise of her sense of touch, some notion of the great size of the ship. Coming up the ladder at the side gave her an idea of the height, and then a walk from stem to stern an estimate of the length. It was touching to see the radiant smile on this poor girl's face as she listened to the boy, who told her what wonders he saw."

Notices of Books.

Journal of the Society of Telegraph Engineers. London: F. & N. Spon.

The ninth number of this useful Journal has just been issued, and it is announced to be published quarterly for the future. Its appearance has hitherto been very fitful, and its regular publication will be a great improvement, for it is a most valuable periodical, and is very ably edited. We have full reports of the discussion upon Mr. Fahie's paper "On faults in Submarine Telegraph Cables," read on November 11th, 1874; upon Mr. Gavey's paper "On Earth-boring for Telegraph Poles,"

read November, 25th, 1874; and upon Lieut. Jekyll's paper "On the Telegraph and the Ashantee War," read December 9th, 1874.—There are interesting articles on telegraphic progress in 1874, Home, Foreign, and Colonial. Several valuable communications in other journals are reprinted, and there are two interesting papers on duplex telegraphy—the first from New Zealand, by Mr. C. Lemon, clear, precise, and practical; the other from India, by Mr. L. Schwendler, full of valuable information, but a burlesque on mathematical analysis. The tendency to put simple logical deductions into algebraic language and call it mathematics is very much on the increase. When this is done on false premises and any operation attempted upon it, the result is very likely to land the would-be mathematician in a quagmire. This is very nearly the case with this communication from India, in which the "general results" are not in accord with experience.

Transactions of the Telegraph Electrical Society of Melbourne.

We have received the second number of the transactions of this useful Society, which now numbers 120 members. It contains a paper by Mr. Geo. Smivert, on the "Origin of the Voltaic Current," favouring the contact theory; one by Mr. D. J. McGauran, "On the transmission of two messages in the same direction at the same time on one wire," which we reprint, and one on "Galvanic Batteries," by the same author, being part of a course of instruction about to be pursued in the Society. The Society is adopting a wise and profitable course, and we wish it every success.

Protection of Life and Property from Lightning during Thunderstorms, by W. McGregor. Bedford: W. J. Robinson.

This is an interesting little compilation, intended by its cheapness to make more public and general views and opinions which have been propounded to a limited circle in scientific books and before several scientific institutions. It is based on a short paper read by the author before the Bedfordshire Natural History Society on the 10th June, and it contains numerous extracts from the works of Dela Riv, Ganot, Snow Harris, &c., and from the papers of Dr. Mann and Mr. Preece. The cost is 1s., and we hope it will have an extensive circulation.

PNEUMATIC TELEGRAPHS FOR LONG DISTANCES.

Paper read at the meeting of the Society of Civil Engineers of Paris, on the 4th June, 1875.

By M. A. CRESPIN.

The pneumatic telegraph whose origin dates from an already remote period, has during the last twenty years been in numerous cases brought into practical use, the first application of the system having been made in London by Latimer Clark. That city now possesses the most complete arrangement of the kind. The very important traffic of that great commercial centre requires arrangements of a special description, which have been carried out with the greatest success by the engineer-in-chief of the Post-office, Mr. Culley, and by Mr. Sabine.

After London, Berlin, Paris, and Vienna have successively adopted the new means of communication, and have laid down similar systems of tubes for the service of internal messages.

The favour which this new system, which cannot pretend to vie with electricity in point of capacity, has found is owing solely to the peculiar conditions which arise in the majority of great cities, that is to say, that the telegraph service is, in such cases, called upon to transmit a large number of messages over distances, comparatively, very short. Under such circumstances electricity is surpassed in speed by modes of transit whose action is much less instantaneous, but whose capacity for transmission is very much greater.

In order to render this rather abstract explanation more complete, I will take for example the case of a telegraphic wire having to transmit a certain number of messages over a distance of no more than one thousand metres, and I will compare with it a pneumatic tube performing a similar service. The wire will transmit the messages one by one, and it will not be able to send more than forty in an hour; a clerk must be employed at each end. By means of the tube the distance will be traversed in one minute, and a hundred messages can easily be carried; these messages can besides be the actual manuscripts, can be secret, and the apparatus being only affected by the bulk and weight of the messages, no matter how many words may be contained in the message, the transmission is equally rapid, and but two attendants are required. The case cited above is one in which the tube has a most incontestable advantage over the electric wire. It is easy to perceive that this advantage diminishes as the number of messages to be transmitted decreases, and it diminishes also as the distance which separates the two points increases. There arrives, therefore, a time when the wire regains the advantage; that is when it is able to transmit all the messages which have to be forwarded in a shorter time than it would take the tube to convey them over the same distance.

This method of collecting and distributing messages in great cities gives excellent results in all cases where the traffic is considerable. The arrangements established in the different cities vary according to the method of working, but the principle is always the same, and may be summed up as follows:—A tube, as perfectly round as possible, connects the two points which are to be placed in communication: one or more boxes (carriers) containing the messages are introduced into the tube by an apparatus, the essential features of which are always the same—that is to say, the tube is closed behind, and a branch tube opening into the main tube between the end of the latter and the train (boxes or carriers), directs a current of compressed air into the tube, producing a pressure H greater than the atmospheric pressure h, which acts at the other end. It is under the influence of this difference of pressure, $H-h$, that the train is driven forward along the line, continually receding from the point at which the compressed air is introduced.

When a message has to be brought in the reverse direction, the same point is placed in communication with a reservoir, in which the pressure is less than the atmospheric pressure h, which acts at the other end. $H-h$ is now negative, and the train placed at the extremity of the line is drawn back to the original point of departure, where it arrives at the end of a certain time. The suction of air is then stopped by the simple closing of a stop-cock,

and a door similar to that used for the sending allows the train to be taken out of the tube. An electrical communication is provided, by means of which the attendants, placed at the ends of the table, are able to control and direct all their operations.

The method employed for compressing the air and producing the vacuum may be any one of the methods by which this class of work can be performed. It appears, however, after different trials, that steam-engines, with direct-acting air-pumps, have been found to work with the greatest regularity, and have consequently been adopted almost universally in cities possessing pneumatic telegraphs.

As regards the circulation, this is effected either by a circular network, worked continuously or alternately, according to the importance of the traffic, or by a radiating system worked in the same manner. In both cases pressure is used for impelling the trains forward, and vacuum for drawing them inwards. The radiating system seems to have been established at the commencement, as being the most simple, and it has been maintained where the traffic is very important on account of its affording a service of the most direct character. The largest system of this kind is that of London, where special arrangements are made by which the tubes are traversed by continuous currents of air, into which the boxes or carriers to be forwarded are introduced by means of a species of sluice, the boxes received being taken out as they arrive by the same means. One of the first systems proposed for Paris, in 1860, by M. Antoine Kieffer, was arranged in a similar manner.

Pamphlet by M. Amédée Sebillot.—In 1866, when the first pneumatic lines were established in Paris, this system was not adopted, and the first works of the kind, executed in Paris by MM. Mignon and Rouart, were carried out upon the network principle, and worked by intermittent currents of messages at regular intervals, a mode of working which is more economical than the former, although rather less rapid.

After this short descriptive account, I come to the object of my paper. In the first place, I propose the following question:—

What are the laws which regulate approximately the movement of boxes in pneumatic tubes?

Experiment shows that the presence or absence of the train in a tube has but little influence upon the flow of the air, that the flow takes place under conditions almost identical with those which govern the flow of other fluids, and that the laws which are observed to prevail in the case of these other fluids can, without risk of too much error, be applied to the particular case now under consideration.

Let R be the resistance to the movement, l the length, X the perimeter, u the speed, a and b coefficients; the approximate formula for the flow of fluids is—

$$R = l X (au + bu^2)$$

Disregarding the term where the speed is in the first degree, the formula becomes—

$$R = b\,l\,X\,u^2$$

The force which causes the boxes to move being equal to the difference of pressure (H—h) multiplied by the section S upon which it is applied, the formula of the movement will be approximately—

$$(H-h)\,S = b\,l\,X\,u^2$$

which, in the case where the section is a circle, becomes—

$$H-h = \frac{8\,b\,l\,u^2}{D} \therefore u = A\sqrt{\frac{(H-h)D}{l}}$$

A formula which numerous experiments have shown to be sensibly correct for the conditions under which pneumatic tubes are usually established and worked, and which shows that the speed varies as the roots of all the conditions of the case, directly for pressure and diameter, universally for length.

As we are considering the means to be employed in order to construct a line of a length l, as great as possible, let us examine successively the influence of each of the forces or dimensions which affect the speed under these conditions.

The first thing to examine is certainly the pressure, or rather the difference of the moving pressure (H—h). The general formula shows that if we were to increase (H—h) and l in the same proportion, a constant speed would be obtained.

Unfortunately, this simple solution is an impossible one, for the practical means at our disposal do not allow of air being compressed at a sufficiently low cost; beyond a certain limit which is 1 effective atmosphere, or 2 atmospheres at most, the cost of compressing (owing to the great outlay necessary) is so considerable that if such a method of working were adopted, even supposing no obstacles were encountered from the elevation of the temperature and the moisture of the air, it would be impossible to organize a remunerative service. A limit would besides be quickly reached, for even by very costly processes, it is with the greatest difficulty that a pressure of from 5 to 6 atmospheres can be exceeded.

In the same way with vacuum. In continuous working a vacuum of much more than 0·50 metres of mercury cannot be depended upon. In conclusion, a pneumatic line arranged for economical working must not require a pressure of more than 2 atmospheres at most, nor a vacuum of more than 0·55 metres of mercury.

The second point to be examined is the diameter of the tube. Here it seems evident that no mechanical difficulty prevents a considerable increase, the formula shows that by increasing in the same proportion as the length, a constant speed will be obtained; experiment confirms this conclusion satisfactorily as regards the speed, and, in fact, the speed is generally found to exceed that shown by the formula. Unfortunately this plan would be too costly: it would result in the laying of very large tubes between points very far apart, even when the traffic between these points might be very small. Now, the cost of laying a pneumatic line increases very quickly with the diameter, much faster than the diameter, and the cost of working increases more quickly than the square of the diameter. It follows, from what has been previously stated, that, in laying a pneumatic line, the only point to be taken into consideration in fixing the diameter of the tube is the amount of the traffic to be conveyed by it, and we shall see further on, that to accommodate an important traffic, it is not necessary to exceed a section which, at first sight, appears extremely small.

(To be Continued

THE TELEGRAPHIC JOURNAL.

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ON A SYSTEM OF TELEGRAPHY.

A Course of Lectures, delivered at the School of Military Engineering, Chatham,

By W. H. PREECE, Member Inst. C.E., &c.

Lecture I.—A System of Telegraphy as applied to Railway Purposes.

The subject of Telegraphy—upon which I have been invited to lecture to you—has been well nigh exhausted by the eminent lecturers who have preceded me. Professor Fleeming Jenkin detailed to you, with that clearness for which he is so celebrated, all that was then known—and little has since been added—of the theoretical branch of the subject; Mr. Culley developed before you all that was then known, to which little or nothing has since been added of the practical bearing of this subject; and Mr. Sabine indoctrinated you into the mysteries and intricacies of Submarine Telegraphy. Your own *Professional Papers* contain a vast store of valuable information on both the theory and practice of Telegraphy, so that apparently there is little left for the lecturer to submit to you upon this subject without retracing ground that has already been crossed.

The Art of War, however, has been well nigh revolutionized during the last few years, and no fact has been brought out with greater force than that in all future wars the railway and the telegraph, jointly and separately, must play a fundamental part.

In America, manœuvres on a grand scale were undertaken to destroy the enemy's railways and telegraphs, and in the great seven weeks' war between Prussia and Austria the value to the enemy of the creation of obstructions to these communications, and to the invaders of their rapid removal, was one of the chief lessons learnt. Even in our little war in Ashantee the complete equipment of a section of a railway has been sent out, though—apparently, and unfortunately—its adoption has been found impracticable, and at the last moment a fully equipped telegraph has followed. In Abyssinia the telegraph, as well as the little railway of 12 miles long, played a most important part; and though it would be too much to say that without them the result would not have been so successful, there is no doubt that with them the advance was expedited and the return hastened. Indeed the experience gained in Abyssinia has probably led to the spirited action of the War Office in the Gold Coast Railway.

The rapidity and completeness of the successes of the Germans in the late—as well as in the seven weeks' war—were unquestionably due to the facilities offered conjointly by the railways and the telegraphs, and the skill and forethought with which they were utilized. In fact it is said that, with the wires in his tent, Count Moltke was able to manœuvre his forces as the chess-player would make his moves upon the table before him. On the other hand for two days during a very critical period the French Emperor was left without news of any kind of MacMahon and De Failly, and the great trial which is now progressing at Versailles gives plenty of evidence of the fact that although the telegraph was much used by the French, their generals were manœuvreing in the dark from the absence of that light which was supplied to the Germans by their efficiently organized telegraph. The character of the French renders them eminently theoretical in their ideas. Their plans and systems partake much of this nature. Before the war their railway and telegraph arrangements were theoretically all that could be desired, but tested by the severe ordeal of real practice they collapsed. The German plan, on the contrary, conceived by the severe logical method of that nation, experienced the pruning of practice in the seven weeks' war, and their system consequently proved a wonderful success.

I read in the *Pall Mall Gazette* for January 18th, 1873. "The importance of railway corps in time of war is constantly enforced upon us by the steps taken by Continental nations in this direction. It would seem that the necessity for such a trained service is held abroad to be one of the most obvious lessons of the late war. The military provisions of the abortive, or at least suspended, Swiss Constitution were intended to pave the way among other improvements to the promotion of a complete railway staff suitable for the exigencies of war, though maintained according to the ordinary Swiss principle, in a normal state of non-activity in time of peace, being, in fact, exercised only occasionally at convenient times. In Prussia we have just seen the Railway Abtheilung of 1870 enlarged into a complete engineer railway battalion. This is being initiated in France; and now Bavaria has created her own organization for the same purpose, modelled also on that of Prussia, but of more modest dimensions, being but one-fourth the strength of that maintained at Berlin. This new formation is a railway company with a peace establishment of six officers, twenty non-commissioned officers, and 104 rank and file, the last to be doubled from the reserve when the company takes its war footing. The corps is clothed as the engineers, but with a small distinctive mark, and in peace is to be subject to the same training and inspection. In war it is to be invariably attached to the headquarters of the First Corps. Its station for the present is at the fortress of Ingoldstadt, the chief strong place now exclusively in Bavarian hands."

In Austria there is a semi-civil organization which is intended on service to be placed under a civil chief. In Russia officers and men are distributed among the Railway Companies to learn railway duties. The Italians have increased each battalion of engineers by one railway company, and have established a very efficient system. France, with marvellous energy, has acted upon the lessons taught her by the collapse of her system and the success of that of the Germans. They have established a recognized military railway department, so as to secure unity of command, centralization of power, and a proper association in time of war of the military and civil elements. They are associating the technical railway staff with the military element by distributing soldiers among the principal railways and recruiting the ranks from the railway services.

I fear none of us individually take advantage

of the experience of others. We simply regard the lessons we learn ourselves. It is so with nations. We see around us the grand military nations of Europe availing themselves actively of the experiences of the past, while we remain comparatively passive, or else make feeble copies of what others do.

Captain Tyler, R.E., no mean authority on railway matters, said before you in this room, "one single line of railway, properly laid, maintained, worked and guarded, is sufficient to keep up the necessary supplies of an army of almost any size." You have had personal experience of their efficiency in the Crimea, Abyssinia, and India, and we know the important part they played in the great civil war in America. They were used in the concentration of the French in Piedmont in 1859, and the Austrians brought up reinforcements by their aid during the battle of Magenta.

Since, therefore, we may conclude that railways and telegraphs will form a fundamental feature in all future wars, it is evident that the relations which they bear to each other, and the organization under which each must be administered separately and conjointly will form an essential feature in the education of our future Royal Engineers. In fact, the time must come when you will have Railway Companies as you now have Telegraph Companies, trained under a well organized system, and maintained in the healthy discipline of the constant and daily routine of practical duties. I have therefore determined to discuss before you the application of a system of telegraphy, 1st, to *Railway Working*, to show how the marshalling and movement of trains, their safety, regularity, and dispatch, depend essentially upon the use of the telegraph. 2ndly, to *Commercial Purposes*, to show how the support and control—if by control is meant the commisariat—of armies is dependent on the continuance of the commercial system in an invaded country. 3rdly, to *National and Imperial Purposes* in time of peace as well as of war; and lastly, to *Military Purposes* pure and simple.

I shall have to deal with these subjects in the short time allowed me more in a general than a particular sense, and to point out to you more their organization than their details. Indeed I conceive organization to be the point upon which information is chiefly needed, for details often shape themselves. Still there is an imperative necessity for him who is at the head of any branch of any profession to be complete master of all the details of his branch. "For want of a nail the shoe was lost." For want of knowledge of details armies have been lost. It is the marvellous knowledge of details which Mr. Scudamore possesses which has enabled him to administer the telegraph department of this country with such success; and the best administrators of our railway system are those who are cognizant of the minutest details of every branch of the service regulated by them.

I would strongly counsel all those who are placed in command of any telegraph work not to content themselves with the mere knowledge of the mode of operating an instrument or transmitting a message, but to master the scientific details and construction of the "wonder-working wire." Smiles says of the Duke of Wellington that "he habitually attended to the minutest details of all matters entrusted to him, whether civil or military. His business faculty was his genius, the genius of common sense, and it is not perhaps saying too much to aver that it was because he was a first-rate man of business that he never lost a battle." The Duke, had he lived in the present day, would have made himself something of a electrician as well as a railway manager; and those who aspire to be leaders must apply themselves to those simple, beautiful, and marvellous scientific principles upon which telegraphy is chiefly based.

But we have to-day to deal with—

Railways.

The rapid manner in which the Germans concentrated their armies for the defence of the Rhine, the skill with which they repaired and employed the French lines for their advance, for their supplies, for the return of the sick and wounded, and for the removal of the multitude of prisoners secured by their successes, show the value of a well organized system of managing railways; but there were not wanting *contretemps* to show the need of improvement in organization and the necessity of a thorough knowledge of railway working.

About the middle of December, General Faidherbe, taking the initiative, advanced on Amiens to meet General Manteuffel, and the result was the battle of the Halluc. It was highly important to the Germans that reinforcements should be rapidly brought up from Rouen. Six battalions were placed at the disposal of Manteuffel, but only two battalions arrived before the battle, two whilst it was being fought, and the remaining two the day after. The French having retreated, Manteuffel was able to comply with the urgent request of the General Commanding at Rouen, and to send back at once four out of the six battalions which had been borrowed. The return journey commenced on the 26th—only one battalion reached Rouen on that day, the three others not before the 28th and 29th.

In this particular instance the chief cause of delay was the want of rolling stock and engine drivers, but considering the distances concerned, it is evident that there were other causes which interfered with that prompt transport which sound organization secures. It forcibly shows the necessity of a knowledge of railways and railway working, and the attachment of a complete railway organization to the head quarters of an invading army.

Bourbaki's ill-success in the East was due to the collapse of the French system, and even with the Germans, French prisoners were kept three days in open wagons in intensely cold weather, whereby some of them were frozen to death.

The railway system of this country is a pure example of the principle of natural selection and of the survival of the fittest. Each railway company has passed through a similar course of creation and education. The teachings of experience are better than tall talk, and therefore in pointing out to you the gradual formation of a railway system in England, and of the united influence of evolution and experience, I think I shall best fulfil my duty as your mentor. I select that portion of the country with which I am most familiar, viz., the south-west, and in which I have not been an idler nor without having assisted somewhat in the process of organization. The success of the Manchester and Liverpool Railway

led to many schemes. Stephenson and Locke who were there associated, separated, and the latter projected the London and South Western Line. The first through portion of this line opened was that between London and Southampton, in 1840. It was a double narrow gauge line. Only four trains were run each way each day. There was no telegraph. The trains were so few, they were separated by such a wide interval of time, that little or no danger existed. A high signal post, of a half moon pattern, was fixed at each station to warn an approaching engine-driver of obstruction when shunting and other operations were going on. The half moon seen wholly or partially on the left hand side was "obstruction" or "danger," and an intimation to the driver to stop at once; seen edge-wise or entirely on the right hand side it was "line clear," "go ahead." On the earlier lines the signals were entirely given by men with flags of different colours by day, and with burning tarred ropes by night.

The double railway was subsequently extended to Gosport in 1842, and to Portsmouth in 1848. It was then found at a busy junction, as Bishopstoke became, that a mere home signal was not sufficient to stop the driver, hence an auxiliary or distant signal was fixed 600 or 700 yards away from the station, which gave him the earliest instruction of the condition of the home signal. At night lamps were used, and their signification is given by the couplet:—

White means *right*, *red* means *wrong*,
Green means *slowly go along*.

And this system which I have described is that, in point of fact, which is in universal use throughout the railway world. Whenever or wherever danger exists from a stopping train, or from a train fouling a line at a junction or siding, a signal is erected, intimating to the driver of an approaching train, "danger" or "all right." A third signal,—the *caution* signal—is sometimes used, but its use is fast disappearing. To give the earliest intimation of this signal, distant signals are fixed as far off as possible, repeating the home signals. Sometimes they are worked together, sometimes they are worked independently of each other, but the principle remains the same. Innumerable forms of signal have been employed, but the semaphore is the favourite, and upon the principle of the survival of the fittest, there is no doubt that it will ultimately supplant every other form of signal. Its great advantage is, that seen from every point of view, its indications mean the same thing. This is not so with discs; seen at different angles they have different meanings.

(To be Continued.)

ON TELEGRAPH CONSTRUCTION.

By JOHN GAVEY, Assoc. Soc. T. E.

(Continued from page 178.)

THE following table, extracted from "Anderson's Strength of Materials," gives the force in lbs. per square inch necessary to cause rupture, both by a tensile strain, and by a crushing force; in the latter case only short pillars are referred to:—

Strength of timber to resist tensile and crushing forces.

Description of timber.	Tenacity in the per square inch of section.	Resistance to crushing per square inch of such.
Ash	15,784 to 19,600	8,683 to 9,363
Beech	11,500 „ 22.200	9,363 „ 7,733
Elm	13,489 „ 14.400	10,331
American Pine ..	12,000	5,375 to 6,819
Memel Pine ..	11,000	
Riga Pine	12,600	
Larch Fir	10,200	
Oak, English ..	15,000	6,484 to 10,058
„ African ..	14,400	
Canadian	12,000	7,731
Dantzic	14,500	12,101
Teak	8,200 to 15,000	

The resistance to a shearing force is about equal to the tensile strength of the timber across the fibres, when the force is transverse to them; and with the fibres, when it tends to rend them longitudinally. The transverse strength is that most called into requisition in telegraph construction, and the following table, the particulars of which have likewise been obtained from Anderson's work, gives the force necessary to fracture beams supported at both ends, one foot long and one inch square when loaded at the centre. The method of calculating from such a table the strength of any beam, when exposed to strain, will be dealt with, when we consider the actual erection of a line of telegraph. The results are those obtained by various experimenters, but the mean maximum and minimum only are quoted here. It may be assumed that, in obtaining these results, heart timber alone would be used, and that beams, containing any considerable proportion of sap wood, would be far inferior in strength, as compared with these figures.

Table of Transverse strengths of beams of timber, one foot long and one inch square when loaded at the centre.

Description of timber.	Force in lbs. to cause fracture.			No. of results.	No. of experimenters.
	Mean.	Maximum.	Minimum.		
Ash	690	810	595	7	5
Beech	623	704	518	4	3
Elm	405	540	343	4	3
American Pine ..	523	483	570	3	2
Memel „	561	577	545	2	1
Riga Fir ..	457	584	369	5	5
Larch Fir ..	440	632	284	5	3
English Oak ..	591	964	420	7	5
African Oak ..	855	855	855	1	1
Canadian ..	580	589	572	2	2
Dantzic ..	514	659	392	3	3
Teak	814	1,075	642	4	4

It will be obvious, both from an examination of the last table, and from the most cursory consideration of the subject, that the strength of any given class of timber will depend on so many different circumstances, such as rapidity of growth, soil, climate, state of seasoning, &c., that no hard and fast rule can be laid down for ascertaining the

strength of any given consignment, and that actual experiments on a greater or lesser scale become necessary if accurate results are desired. Such accuracy, however, although needed in calculations for extensive engineering and architectural works, are not generally necessary in telegraph construction. Further, it appears to be a generally accepted opinon, that creosoting, boucherising, and other like preservative processes, perceptibly weaken the timber which undergoes them, rendering it "short," or in other words, liable to fracture under sudden or prolonged strains, more readily than ordinary seasoned timber. Definite experiments in this direction are wanting, and such would be of a highly interesting nature, if carefully carried out. It is, however, an undoubted fact that many railway companies have abandoned creosote for sleepers exposed to a heavy traffic, as the chairs cut their way more readily into the wood under the constant impact of passing trains than when it is merely seasoned in the usual manner; the timber being thereby more rapidly destroyed mechanically than ordinary timber would be by rot.

In selecting or purchasing timber, the following points should meet with particular attention. All poles should be sound, hard grown, straight, and free from large or dead knots and other defects. These should contain the natural butt of the tree, and be free from evidences of decay at the core when felled. They should be of slow growth, as in such a case there will be a lesser proportion of sap wood, and consequently they will possess greater strength and a less liability to decay. The rapidity or otherwise of the growth is seen by the dimensions of the "annual rings," and the proportion of sap and heart wood respectively is easily distinguished in a felled tree by the difference in colour and solidity. If timber is to undergo a preservative process, the amount of sap wood is not so material, as it will then affect the strength of the timber only, and not its durability. The diminished strength can be allowed for by increasing the dimensions.

The timber should be felled in winter say between the 1st day of November and the 28th February.

If poles have to be treated with preservative compounds, they should not be floated to the works, or exposed to the liability of becoming saturated with water in transit, for this vitiates the success of the subsequent operations, unless much loss of time is incurred in thoroughly drying out the absorbed moisture. They should, on delivery, be cross-stacked, so as to admit of a free circulation of air around and through them, for at least three months before they are immersed in the tanks; and they should be thoroughly dry when this is done. Poles in depot should, whenever possible, always be stacked at such a height from the ground as to be beyond the reach of vegetation. Further, each tier should be separated from the next ones by layers of dry sound timber, techinially termed *dunnage*. This allows a free circulation of air, and prevents the accumulation of damp, the formation of fungus, and the setting in of circumstances favourable to decay. This point is not material with creosoted timber.

The dimensions of telegraph poles of course vary with the class of line to be erected. The average lengths to be used have been referred to already. The diameters depend entirely on the number of wires to be carried. For one or two wires, poles 4 inches in diameter at the top will serve for three or four wires not less than five inches, and above that number six inches should be the minimum, a few poles of larger dimensions than the minimum, in every class of work, should always be provided for use in special cases. The theoretical law for obtaining the maximum strength, from a given quantity of timber, will be dealt with later, but in the meantime the following dimensions may be quoted as those frequently used. The poles are roughly divided into two classes, light and heavy, the former serving say for lines up to four wires, the latter for main lines:—

Length.	Light Poles.		Heavy Poles.	
	Diameter at top.	Diameter 5 ft. from butt.	Diameter at top.	Diameter 5 ft. from butt.
20 feet	$4\frac{1}{2}$	$6\frac{1}{2}$	..	..
26 "	5	$7\frac{1}{2}$	$5\frac{3}{4}$	$8\frac{1}{2}$
30 "	5	8	6	$9\frac{1}{2}$
36 "	$5\frac{1}{2}$	$9\frac{1}{2}$	$6\frac{1}{2}$	10
40 "	$5\frac{1}{2}$	10	$6\frac{1}{2}$	11

(To be continued.)

GRAMME'S MAGNETO-ELECTRIC MACHINES.

By ALFRED NIAUDET-BREQUET.

(Continued from page 186.)

PECULIARITIES OF THE MACHINE.

FROM what has been said regarding its principle, it may be easily understood how continuous currents are supplied, and how their direction will change with the direction of rotation.

The continuity of the current is manifestly owing to the circumstance that the movement of the machine is continuous; that the circuit is never broken, since the rubbers or brushes begin to touch one of the pieces R before abandoning the preceding one, and because the flexible and multiple nature of these brushes guarantees that they always touch a "piece" by some one of its parts.

The strength of the current increases with the speed of rotation; experiments have proved that the electro-motive force is proportional to the speed. This has been several times completely verified in England and France—notably by the inventor himself by means of a small steam-motor of extremely regular movement.

At first sight it would seem that the resistance should remain constant; but it was soon noticed that the strength is not proportional to the speed of an invariable circuit, whence one is led to conclude that the resistance of the machine to the passage of the current is not constant. This important fact was pointed out for the first time by Mr. Robert Sabine. The increment of resistance is, however, small; so small that it may be safely admitted that a machine which gives, with a speed of 100 turns in a minute, a current equal to 1 Bunsen's element of small size, gives a current equal to 2 Bunsen's elements (of rather larger size) with 200 turns per minute; it will also give a current of 4 Bunsen's elements (rather larger still) with a speed of 400 turns a minute, and so on. This augmentation of the electro-motive force cannot be indefinite: it tends to a limit. But, as with speeds of 3,000 turns a minute the before mentioned proportionality still subsists, it may be

granted that the limit is far from being attained, and answers to a speed almost impossible to realise in practice.

Upon the whole, M. Gramme's machine gives continuous currents similar to a battery; currents constant, if the movement be uniform; currents variable at will between very extended limits according to the speed of the rotatory movement.

To suit the purposes for which his machines are required, the inventor modifies them by winding upon the ring thin or thick wire, so as to produce either "intensity" or "quantity" effects. It appears indubitable that according to the speed of the ring the electro-motive force will be proportional to the number of helices, or coils of wire; but interior resistance increases in the same proportion, and in most cases best results are obtained by using thick wires. However, where the exterior circuit is of great resistance, as in telegraphy, it is better to use machines having thin wire.

Gramme Machines, without Permanent Magnets.

Those who have followed the progress of electro-magnetic motors for some fifteen years will remark that one of the chief improvements in the English machines consists in replacing the existing magnets of Pixii's, Saxton's, and Clarke's machines, with much more powerful *electro-magnets*, themselves excited by the action of the machine.

For small apparatus, M. Jamin's recent discovery of the means of procuring magnets of an extraordinary power at a relatively low cost, considerably lessens the importance of the preceding combination. But for industrial engines the use of electro instead of permanent magnets is rendered almost absolutely necessary.

It might be supposed that the magnetism induced in the electro-magnets would entail a considerable waste of electricity and force. M. Gramme shows, however, that this difficulty may be turned to account. If an electro-magnet is placed in the circuit of a Gramme machine, the current given out in the first instance magnetises it, and afterwards maintains its magnetism. It cannot be doubted that the production of this magnetism in the first almost instantaneous period does respond to a certain waste of electricity and force; but in the second period, what takes place? Reflection and experiment demonstrate that there is still a waste of electricity, and therefore of mechanical power. But M. Gramme has thought, not without reason, that the magnetic equilibrium once obtained, its maintenance would not require an expenditure of work any more than work would be required to maintain the support of a weight at a level to which it had been raised. He concluded that almost all the waste took place simply in the current's passage in the wire, and that it would be almost the same if the wire, instead of being wound in coils upon iron cores, was merely extended in a straight line.

He was thus induced to place the moveable ring, the exciting electro-magnet, and the electrical receiving apparatus (whether electroplating bath, or electric lamp) in one circuit. Under these circumstances it was useless to have two distinct rings—the one to excite the electro-magnets, the other to generate electricity for use: one ring only sufficed.

The wire wound round the electro-magnets adds a resistance to the circuit, and thus diminishes, in an inevitable manner, the strength of the current; but the shorter and thicker the wire the less is the strength of the current reduced: hence thick and short wire is used in all cases where practicable. For this reason he uses in some instances not wires but sheets of red copper as wide as the electro-magnet is long, and which are wound round upon themselves four or five times in spirals. We may therefore say that the force necessary to magnetise the exciting electro-magnets of these machines is almost nothing.

In order to obtain a high potential, a slight alteration has been made in the ring or "annular helix." It has already been described as consisting of 60 coils or elements in electrical communication with radiating pieces from which the current is collected by rubbers. M. Gramme has adopted the plan of putting on the right hand side of the ring all the *ingress* ends of 30 alternate coils, and on the left hand side all the *ingress* ends of the remaining 30 coils, as may be seen from Figure 8. The total sum of the force produced is thus divided into two parts collected by separate brushes—one on either side.

The advantages resulting from this arrangement are very great. It permits the battery to be joined up for either "intensity" or "quantity" purposes, so as to obtain very varied effects from the same machine, and to accomplish this by means of a simple commutator action. There are reasons for believing that a ring and its collecting-rubbers behave better when the machine is thus divided, and that each of the two portions of the divided ring is in a better condition for work than is an ordinary single ring. The last word, as regards this question, has not however yet been given.

Inverse Work.

Like all other magneto-electric machines, Gramme's has for its chief function the conversion of mechanical force into electricity; by the reconversion of electricity into a motive force it becomes an electro-magnetic machine. It has been found that by merely applying an electric source to the metallic brushes, the central ring immediately moves.

Having neither connection rod nor crank, &c., this instrument is eminently successful in producing work out of an electric current, as shown by the following results obtained out of a current from 2 to 10 Bunsen's elements of 20 centimetres each, and one of Jamin's magnets:—

Number of Elements.	Number of turns of the Ring.	Force in Kilogrammes.	Remarks.
2	760	0·320	Action irregular.
3	810	1·020	„ good.
4	1,000	1·600	—
4	900	1·800	—
5	1,100	2·500	—
6	1,000	3·360	„ irregular.
7	1,100	3·140	„ good.
8	1,100	5·000	—
8	900	4·807	—
9	1,500	5·115	The check balanced with great difficulty.
10	1,700	5·520	Action good.
10	1,300	6·165	„ irregular.

A striking experiment consists in placing two small Gramme's machines in the same circuit. If one is set in motion it furnishes a current which which passes into the second, and sets it likewise in motion. If the first is stopped, and the movement instantly continued in the contrary direction, the second also suddenly stops and resumes an inverse movement.

The following experiment is also not without interest. If the machine is turned and its current passed into a Planté's secondary battery, the battery becomes charged. On ceasing to turn and keeping the circuit entire, it will be found that the secondary current returns to the machine and causes the ring to turn in the same direction and for a similar period as before.

TRANSFORMATION OF "QUANTITY" INTO "INTENSITY" ELECTRICITY.

Just as Ruhmkorff's coils transform quantity electricity in the primary wire into intensity electricity induced in the secondary wires, so Monsr. Gramme has recently shown* that his machine will act in the same way. For this purpose he makes use of a "double ring," whose even coils are made of fine wire, and whose uneven coils are of coarse wire. This ring is placed between the poles of a magnet as in Fig. 4.

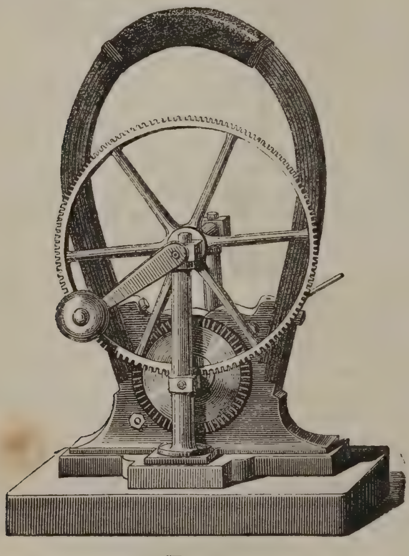


FIG. 4.

Let a battery current from two Bunsen's elements, be passed into the coarse wire, the ring begins to turn as already explained. Under this rotary influence, it will induce in the fine wire coils an ordinary "Gramme machine current;" but this induced current will be of much greater "intensity" than the Bunsen current. The ratio between the two currents is found as 1 to 8; for the current from 2 of Bunsen's elements induced another equal to 16 Bunsen's elements, equivalent to about 30 of Daniell's elements. Inversely we may obtain from a high intensity current one of quantity.

In these transformations there are losses more or less great, which may lead us to paraphrase a mechanical axiom—"*What is gained in "intensity" is lost in quantity, and inversely.*

USE FOR SCIENTIFIC PURPOSES.

Monsr. Mascart was the first to point out the possibility of using this machine as a measure of electro - motive forces. The proportionality of potential to the speed of rotation having been verified between sufficiently extended limits (from 1 to 10 Bunsen), we are able by the method of opposition to measure any electro-motive force whatever by the rotatory speed of the ring during moment of equilibrium.

The speed may be reckoned by two methods—either by means of Deschien's velocimeter, or by a chromoscopic diapason. The velocimeter is an extremely convenient implement; it is simply necessary to affix it for ten or twelve seconds to the extremity of the axis to learn the number of revolutions made during that time.

But it frequently happens that we are not able to maintain the speed rigorously constant for twenty seconds; it is then advisable to use the diapason in the following manner: A small even-surfaced cylinder, coated with candle smoke, is fastened to the axis of the ring; a diapason, vibrating 100 to the second, and bearing a small pen at the end of one of its branches, is then held in the hand. At the precise moment, when the galvanometer indicates the equality of the two electro-motive forces, the pen is applied to the cylinder, and a sinuous line is traced. The application of the pen need be for only a very short time; a half revolution of the ring, indicating some small fraction of a second, being all that is required. Time and space being known, the number of revolutions per second are at once obtained.

The method of opposition theoretically so satisfying is not always easy, and to measure an electromotive force with any exactness, a thermo-electric pile—neither a convenient nor cheap instrument—should be used. The advantage of Gramme's machine in this instance results from the fact that, unlike ordinary batteries, its electro-motive force may take all possible values from zero. As generally known, it is very difficult to obtain a strictly constant battery current; but exciting Gramme's machine by a regular speed induces a current of absolutely even strength.

APPLICATION TO GALVANO-PLASTIC PURPOSES.

The first machine of this description, made by Mons. Gramme in 1872, has worked ever since to the entire satisfaction of the owners. It has required no repairs; and the only expense of maintenance is that of the oil necessary to lubricate it. These machines were made till the commencement of 1873: and the earlier form weighed 750 kilogrammes, everything included, containing four electro magnet bars, and two coils. The weight of the copper used in their construction was 175 kilogrammes. Their dimensions were 1·30 m. high, and 0·80 m. greatest width. They deposited 600 grammes of silver per hour, requiring for this purpose a force of 75 kilogrammetres (exactly one horse-power).

Since then, calculations and experiments have led to the invention of a new and far superior type, as represented by Fig. 6.

It will be observed that it contains but one ring

* *Comptes Rendus de l'Academie des Sciences*, 24th Nov., 1874.

instead of two, and but two bar magnets instead of four. Particulars are as follows:—

Total weight ..	117·50	kilogrammes.
Weight of copper	47·00	,,
Dimensions:—		
Height ..	0·60	metres.
Width ..	0·55	,,
Deposits	600.	grammes of of silver per hour.
Motive force required to work it..	50	kilogrammetres.

exciting coil in placing the electro-magnet in the circuit of the current; and by a better arrangement of the copper fittings. The fittings of the electro-magnets, for instance, were at one time made with round wire, but are now formed of a single band of thin copper, the width of half an electro-magnet bar, so that in reality the two magnets are covered with four bands of copper. The ring or coil is furnished with very thick and flattish wire, offering such sufficient rigidity to sustain the centrifugal force of 500 turns a minute rotary speed. The framework is of great stability, and the minor portions in all respects improved.

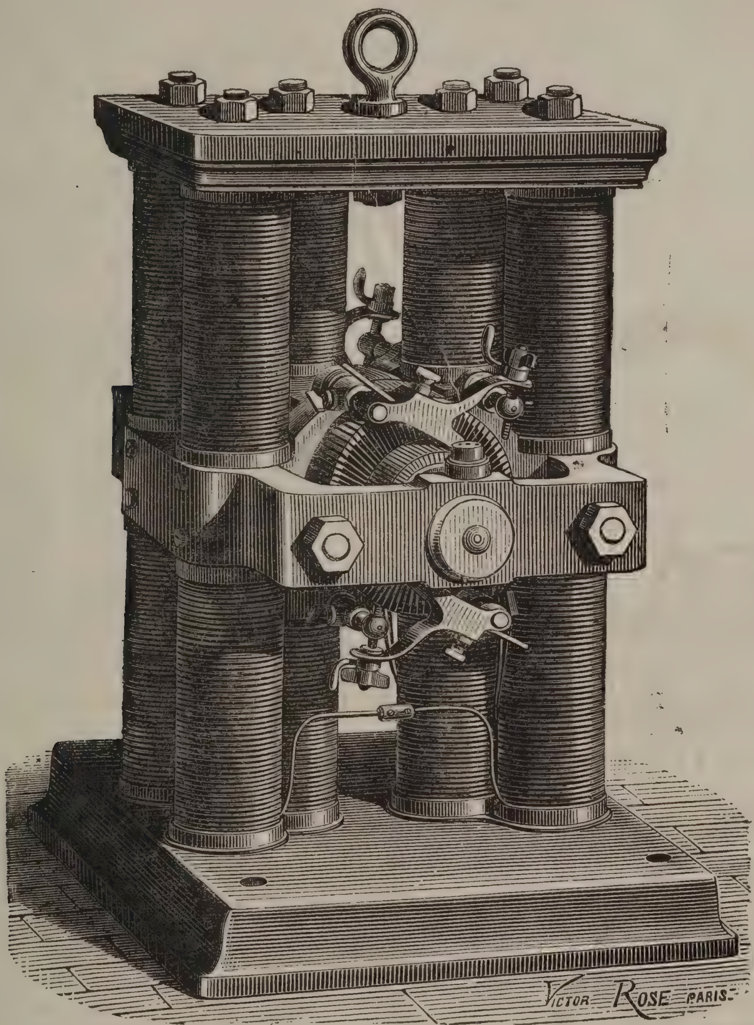


Fig. 6.

This, compared with those previously described, possesses the following advantges:—

1.—Occupies less than half the space.
2.—Total weight reduced by more than three quarters.
3.—Weight of copper reduced by more than three quarters.
4.—30% of motive force economised.

Improvements that are obtained by discarding the The armatures are solidly fixed to the magnets, and embrace almost the entire circumference of the coil.

The arrangement whereby the magnet is placed in the circuit gave rise to an injurious phenomenon of change of pole; for whilst the machines continued in action with circuits closed through metallic baths, the poles remained constant; but, the moment a stoppage took place, a secondary current was immediately set up by the bath, which,

traversing the electro-magnet wires gave them a contrary magnetism: hence, on recommencing rotation an *inverse* work was performed. In the case of silver-plating, for example, if a strap fell, was replaced, and work recommenced, the objects in the bath would be un-silvered. To obviate this inconvenience, on the machine slackening the current is cut off automatically. When, after a stoppage, work is to be continued, all that is required is to close the circuit by bringing a small metallic plate (called a "*current-breaker*") into contact with the electro-magnets.

This "*current-breaker*" is a small moveable counterpoise piece that unites the metallic brushes to the electric-magnets. Whilst these latter are magnetised, the current-breaker remains in contact; but, the moment the machine, by slackened speed, reduces the attractive power of the electro-magnet, the counterpoise balances away so as to break connection between the annular coil and the electro-magnets. No secondary current can form, and therefore the poles remain continuously the same.

(To be continued.)

Notes.

MR. F. J. SCUDAMORE, C.B., whose retirement was recently alluded to, has now ceased his duties, and shortly leaves for the East. A handsome testimonial—a purse of 400 guineas—was presented to him by his brother officers. His vacancy as secretary to the Post Office will not be filled up.

Mr. F. E. Baines, well known to all telegraphists, Mr. Scudamore's chief assistant, has been appointed "Surveyor-General for Telegraphs." Mr. C. H. B. Patey succeeds Mr. Baines as principal clerk of the telegraph branch.

The cable between Dartmouth and Guernsey has been repaired, and communication with the Channel Islands is now restored. It was found necessary to use a large amount of entirely new cable.

A new cable is now being manufactured at Silvertown for the Isle of Man, and it is expected communication will be re-opened in the early part of this month. The original cable, which was laid in 1859, was found so deteriorated that a complete renewal was necessary.

The manufacture of the New Zealand cable has been commenced at the works of the Telegraph Construction Company.

The India Rubber, Gutta Percha, and Telegraph Works Company (Limited) have received the following telegram to-day: "Silver, London—Aug. 11. Arica-Iquique section successfully completed. All well.—GRAY, Iquique." This section is about 200 miles long, and the total length of cable laid on the coast of Peru is about 860 miles.

At the meeting to-day of the Mediterranean Extension Telegraph Company (Limited), the report was adopted, and a dividend at the rate of 3 per cent. per annum was declared, as well as the half-yearly dividend on the 8 per cent. preference stock, and £500 was carried to the reserve fund, making it £7,848.

A letter from San Francisco to the *New York Herald* of the 11th inst. says:—"About one year ago a number of leading capitalists of this coast conceived the idea of forming a joint-stock company for the purpose of constructing telegraph lines between this city and New York and all the principal cities throughout the United States and Canada. The project was discussed from time to time, but no direct action was taken until about two months since, when a company was formed and duly incorporated under the laws of the State for the purpose above stated, with a capital stock of 25,000,000 dollars, divided into 25,000 shares. The amount of stock now actually subscribed is 7,500,000 dollars, of which amount 75,000 dollars has been paid up. The principal promoters of this enterprise are A. A. Cohen, C. W. Kellogg, Michael Reese, J. R. Keene, F. D. Atherton, Mr. Sharm, Mr. Burling. These represent an aggregate capital of 25,000,000 dollars to 30,000,000 dollars. They are among the most prominent men on the coast, and noted men of energy and enterprize and business capacity. They propose commencing to build from Ogden East, and will probably buy the right to use existing line to that point. They say they do not intend doing any business until they have completed the line to New York, continuing with Philadelphia, Washington, Boston, and other of the principal cities—in all about 5,000 miles of telegraph lines. They will extend lines throughout the United States and territories and Canada. The estimated length of the company's lines to be completed is 75,000 miles. The work is to be commenced at once. It is the intention of the company to have the line to new York completed and in working order by next spring. They have already made a proposition to parties in New York to open a construction office there for building the line on that side, and also have advertised for proposals to furnish 30,000 poles of the requisite size. There will doubtless be many objections thrown in the way of this enterprise by the company now in operation; but the promoters of the scheme understand that, and are prepared with rates for commercial business as follows:—Ten words from New York to Philadelphia, 10 cents; New York to Chicago, 50 cents. These are special points. The general rates will be as follows:—Within 250 miles, 25 cents; 250 to 500 miles, 50 cents; 500 to 1,000 miles, 75 cents; over 1,000

miles, one dollar. In addition to this the company' by reason of certain arrangements they expect to make, but which they are not prepared to make public, will establish a system of second-class rates at the following tariff:—Within 250 miles, 10 cents; within 500 miles, 15 cents; within 1,000 miles, 40 cents. The principal promoters of the enterprise say they have not started this company for the purpose of interfering with the business of any other line, but as a business speculation, from which they ultimately expect to receive a fair return. They look on it as a business as necessary as cheap postage, and expect, from the great business, they will receive benefit as stockholders as well as business men."

Correspondence.

Edinbro', August 11, 1875.

To the Editor of the TELEGRAPHIC JOURNAL.

Sir,—At page 150 of your journal it is stated that Mr. De Sauty commenced duplex experiments in Gibraltar in March, 1872.

Could you kindly inform me if this should not be 1873? Yours, &c.,

A. EDEN.

NOTE.—Your Correspondent had the misfortune, at the close of 1872, to propose and experiment on the Bridge method of duplexing (in ignorance of Mr. Stearn's prior invention). It would therefore be interesting to know, if even in Gibraltar, it was being tried eight months prior to my own experiments, although the latter were by double currents, and with automatic transmitters at high speeds. A. E.

[It should have been 1873.—ED. *T.J.*]

GATHERINGS FROM THE EDITOR'S NOTE BOOK.

IN one of his dialogues, called "Ion," Plato asserts the power which enabled the poet of that name to win a prize for recitation at a public festival to be "inspiration—a magnetic influence, passing like an electric current from the loadstone of divine essence into the soul of the poet, and from thence into the souls of his hearers." Plato could know nothing of an electric current, but he had the idea of the transmission of an influence from one point to another, which is best translated by that term.

Terquem proposes the following experiments to prove that electric charge remains on the surface of bodies:—He takes a birdcage and suspends it from the prime conductor. He places inside a gold leaf electroscope, pieces of tinsel, feathers, pith balls, —nothing stirs. He suspends inside and out bundles of threads—those inside are unaffected, those outside are affected. Bands of paper outside are excited, ones inside are not affected. He also introduces a bird which is quite indifferent.

Franklin says that electric charge is destroyed—

1st. By gradually sifting fine sand on the electrified body.
2nd. By breathing on it.
3rd. By making a smoke about it from burning wood.
4th. By *candlelight* suddenly—the light of the sun does not dissipate it.
5th. A bright coal and red-hot iron.

Smoke from dry resin dropped on hot iron is attracted by both bodies.

Franklin imagined electricity to be an element of glass—remove electricity and glass would lose its virtues and properties!

The earth and atmosphere play an important part in all electrical phenomena. If air were not an insulator, electric phenomena would be unknown. Its insulating power varies with its hygrometric state.

According to Ferguson—"Green glass, which contains no lead, is better adapted for the construction of electric apparatus than flint glass, and does not attract moisture to the same extent," but Sir W. Thomson says the very reverse.

Loss of charge in air arises from particles of dust floating about and carrying away electricity by convection, but according to Gavarret—"Air, even perfectly dry, carries away from electrified bodies a portion of the charge accumulated upon their surface. The gaseous layers which immediately envelope an electrified body are themselves electrified at their expense by contact. Consequently, they are charged with fluid, they are repelled and yield to new layers, which in their turn borrow from this body a new dose of electricity which they carry away with them. This inevitable and incessant loss produces a progressive diminution of electric charges, the rapidity of which grows from rest with the hygrometric state of the atmosphere." The above explanation is, however, not in accordance with present ideas.

Faraday showed the polarity of electrified materials by a glass trough filled with oil of turpentine, and inserting in it small fragments of *white silk*. When discharges passed the fragments formed a connected chain, which ceased with the discharges. Matteucci used various powders which always formed a linear series.

In a properly constructed electrometer no external influence should exercise any effect upon the moveable conductors. In present instruments the inner surface of glass is liable to become electrified, and does so. Faraday showed that this could be obviated by coating the interior of the glass case with a fine network of tinfoil. A cage of fine wire inside the glass shade will have the same effect. An electrometer is an instrument for measuring, by means of the motions of a moveable conductor, the difference of potentials of two conducting systems insulated from one another.

PNEUMATIC TELEGRAPHS FOR LONG DISTANCES.

Paper read at the meeting of the Society of Civil Engineers of Paris, on the 4th June, 1875.

By M. A. CRESPIN.

(Continued from page 192.)

In examining arrangements of this nature, one is astonished at the small diameter of the tubes generally adopted; thus, in the great English system at St. Martin's-le-grand, the diameter of the tubes is almost exclusively $2\frac{1}{4}$ inches. Two lines only, the traffic of which is exceptional, and upon which up and down arrangements have been adopted, have been made 3 inches in diameter. The expenditure of air in these tubes is double that in the others, and consequently the English engineers have restricted their use as much as possible.

What is the reason for a size which at first sight appears so small? The answer will be found in examining the conditions under which the line itself is established.

A telegraphic message or a pneumatic letter is always very limited in its size and weight, the amount of matter daily sent through pneumatic tubes by a population of one or two millions of inhabitants is represented by a bulk and weight far from great, and when the comparatively rapid speed with which this matter is passed through the tube is taken into consideration, it is easy to see that it is not at all necessary, in a successful system, for them to be of large dimensions.

Let us make a comparison between the tubes under consideration and other mains or tubes carried underneath the soil in large cities for distributing gas and water, the latter of which, in well supplied towns is furnished to the inhabitants at the rate of about 100 litres per head per day. To afford this, supply mains of about a metre in diameter are employed on the chief routes, and of a smaller diameter on the others; the speed of circulation is at most one metre per second. In the case of the matter conveyed in the pneumatic tubes the amount certainly does not exceed 1 gramme for each inhabitant, or one thousand times less, and the speed in the pneumatic tubes is at least ten times as great; with a section of one millionth, we shall then have made the conditions nearly equal.

If we apply these figures to Paris we find a mean circulation of 10,000 messages per day of 5 grammes each, making a total weight of 50 kilogrammes: these messages distributed into boxes, for passage through the tubes, at the rate of 25 per box, would require 400 boxes or 40 boxes per hour, which could easily be forwarded in four trains despatched at intervals of a quarter of an hour. It is clear that trains might be sent at much more frequent intervals provided, of course, that sufficient power were employed to produce the compressed air and vacuum which would be required.

The tubes employed in Paris have a diameter of 0·065 metres, and would certainly suffice for a traffic of 50,000 messages per day, if the need for for carrying so large a number of messages arose.

In the present state of the question it seems evident that, even taking into account a postal service already well developed, the diameter of a pneumatic tube should never exceed one-tenth of a metre; under these conditions the limit of remunerative cost has been reached, beyond this limit the cost becomes greater than that of a railway. If such a tube is worked by engines of sufficient power, it can transmit as many as 100 boxes per hour, representing nearly 100 kilogrammes weight of messages, which, divided into letters of 20 grammes each, would equal 5,000 of such letters per hour.

It is evident that a traffic of this kind would be far in excess of the amount of work possible at the present time.

We have just seen by what has been previously stated on the subjects of pressure and diameter, that these two elements in the establishment and working of a pneumatic tube, cannot, practically, be extended beyond certain limits; we now proceed to examine the influence of the length itself. We again revert to the fact that all the advantages of a pneumatic telegraph consist in its compensating, by its capacity, for its relative slowness as compared with electricity. It is necessary therefore, if we wish to go far, to go at a high speed; we have just seen within what limits we can avail ourselves of increased pressure and diameter, and the result of our examination is, that a solution of the problem must be sought in some other direction.

The first investigations of the subject date from 1857; they were made by Mr. Latimer Clark, who brought forward the question of the necessity for a mechanical arrangement to allow of the working of lines of comparatively great length. A kind of opening was arranged which was closed by means of special mechanism at the moment a train passed, when the train was being impelled by compressed air, and was opened upon the passage of a train in the opposite direction, drawn inwards by the vacuum.

The advantages of a plan of this kind were indisputable, and we find in the journal *Engineering* of the year 1869 the description of an apparatus proposed by Mr. Sabine, which affords a satisfactory solution of the problem.

Mr. Sabine has taken the case of line similar to one of the principal lines radiating from the Post-office in London, and constituting a line of communication with a point more or less distant by means of trains alternately driven forward by pressure of air, and afterwards drawn back again by a vacuum applied at the end of the tube terminating in the central station.

His arrangement consists of a valve acted upon through a hinged rod by a sort of diaphragm of leather or india-rubber, the latter being influenced through a special tube by the vacuum or pressure at the central station. This diaphragm opens the valve, and when sending by pressure the air, by escaping through the opening, allows the train to traverse the first section as if the line consisted merely of the length between the starting point and the valve. The moment the train passes the opening, it detaches the valve from the rod which connects it with the diaphragm, by the action of a spring; the valve then closes, and the train passes through the second section with the speed proper to a line having the length of the two first sections, and so on.

If the central station draws a train from the extreme end, the apparatus acts in the following manner: by means of the vacuum actuating the diaphragms through the special tube, all the valves

are closed, the line can then be exhausted of air in front of the train which, as it passes the valves, acts upon the bolts, and thus disconnects them, so as to allow the air to enter behind the train at the end of each section; the same advantage is thus obtained as when sending by pressure.

The table given below shows the advantage gained by employing this apparatus; a line of ten sections is taken for example.

No. of Section.	Time of transit in each section.		Total time of transit. With Valve.	Without Valve.		Percentage of gain.
1	1		1	1		
2	$\sqrt{2}$	1·41	2·41	$2\sqrt{2}$	2·82	17
3	$\sqrt{3}$	1·73	4·14	$3\sqrt{3}$	5·19	25·4
4	$\sqrt{4}$	2·00	6·14	$4\sqrt{4}$	8·00	30·3
5	$\sqrt{5}$	2·24	8·38	$5\sqrt{5}$	11·20	33·7
6	$\sqrt{6}$	2·45	10·83	$6\sqrt{6}$	14·70	35·7
7	$\sqrt{7}$	2·65	13·48	$7\sqrt{7}$	18·55	37·6
8	$\sqrt{8}$	2·83	16·31	$8\sqrt{8}$	22·64	38·8
9	$\sqrt{9}$	3·00	19·31	$9\sqrt{9}$	27·00	39·8
10	$\sqrt{10}$	3·16	22·47	$10\sqrt{10}$	31·60	40·6

From this table it is seen that the percentage of gain goes on increasing as the line becomes longer; the gain which is 17 per cent. for a line of two sections, with only one apparatus in the middle, increases to 40 per cent. upon a line of ten sections provided with nine of the apparatus distributed throughout its length.

The remedy is, however, far from being a radical one, for, if it allows pneumatic lines to be extended in length, it limits this extension, and the same table which shows the advantage of the apparatus, shows also very clearly the limit of the same extension; for we see that even with the proposed improvements it takes 3·16 times the time to traverse the tenth section that is necessary to pass through the first, and that averaging the gain over the whole length, the mean time occupied is represented by 22·47 instead of 10, which would be the figure were all the sections traversed at the same speed as the first. The mean speed after the tenth section has been passed is less than one half; the time occupied is nearly three times what it ought to be.

The solution of the problem of a line of unlimited length with a constant speed required a more complete apparatus, and it is this apparatus, to which I have given the name of *relay*, that I am about to describe. Its object is to perform in the most complete and exact manner the operations which would be carried out by an attendant who, under conditions about to be described, would have to act in the following manner.

The pneumatic line of extended length has been, as in the case of lines established within the limits of cities, divided into sections of about one thousand metres in length; each of these sections is furnished at its commencement with reservoirs in which is stored up the compressed air, having the pressure and volume necessary for performing the service of the section. The case is exactly the same as that of an intermediate station in a city, provided with means for compressing air; the two lines up and down are arrranged in a straight line, end to end, in such a way that a train received on the up line can pass without impediment into the down line; the attendant, whose presence we assume, would await the arrival by the up line of a train which was being sent to him, allowing the air to escape freely at the end of the section. At the moment when the train passes from the up line into the down line he closes the former behind the train, and opening a cock communicating with his own reservoir of compressed air, by this means drives the train forward along the next section; he keeps the cock open whilst the train is passing to the next station, and closes it when informed of its arrival at the latter point by the attendant there in waiting.

Such are the varions operations which must be performed automatically by the relay; the first apparatus used and giving certain results was tried in the month of May, 1873. The trials were made in Paris, upon the direct line from the Central Station to the Bourse; and in London, in the engine-room at Telegraph-street.

At Paris the apparatus was placed under a cast-iron plate, and was connected by special pipes with the reservoirs of compressed air in the station at the Théâtre Français.

This apparatus fulfilled exactly all the operations above described as having to be performed by the attendant supposed to be placed at the intermediate station. The escape of the air took place in front of the relay, where a portion of the tube was perforated on all sides so as to give a passage to the air equal to twice the section of the tube. The closing of the line behind the train, and the opening of communication with the compressed air reservoirs were governed by a kind of trigger, acted upon by the train directly it had passed through the relay. The duration of the blowing was determined by a piston rising in a cylinder through the effect of the internal pressure; the rising of this piston was regulated by the counter-pressure in such a way that the blowing continued somewhat longer than the time necessary. The moment a train arrived at its destination or entered a further section the pressure being destroyed in the line the weight of the regulating piston caused it to fall and remain in position to await the arrival of another train.

The success of this apparatus was complete; it enabled a certain number of trains to be passed to and fro between the Central Station and the Bourse with a saving of more than half the time. The return journey was equally rapid, for the trains were sent by pressure as far as the relay, the escape of air taking place through the perforated part of the tube; the rest of the journey was accomplished by means of vacuum from the Central Station.

The objection made to this apparatus is its delicacy; it contains within it a piece easily broken, this piece is the valve employed to close the line; if a foreign body hinders, even partially, its action the relay becomes nothing but an obstacle preventing, in the most absolute manner, the passage of the trains.

To remedy this objection it became necessary to do away with this valve which, after the description which has been just given, would seem to be the essential feature of the apparatus, since it is that which separates the outlet from the inlet. It could only be removed by suppressing the outlet, and to enable the latter to be dispensed with, the counter-pressure must be taken away.

It is this chain of observation which has guided me to the formation of the plan which I now proceed to set forth, and which completely solves the problem. The line is double acting; by means of special apparatus which are also relays, it is kept constantly exhausted of air, and there is consequently no longer any counter-pressure nor are there any valves in the pressure relays.

By the side of the line, which we may assume to be of unlimited length, are laid two secondary tubes connecting the reservoirs of vacuum and compressed air for the supply of the relays, which are placed in convenient positions along the course of the line. These relays are of two kinds, those destined to exhaust the line of air are placed five kilometres apart where it is intended that trains shall be sent along the line at intervals of a quarter of an hour. The reason for their being placed at this distance apart is, that a rather less space of time is needed for exhausting five kilometres, and there is, therefore, no advantage gained by placing them nearer together. They are of a very simple form, a piston rising in a cylinder carries with it a valve closing the line, and a slide opens the communication with the vacuum reservoirs; the piston is raised in the cylinder on the passage of a train, by the counter-pressure which follows the moving power, it closes the line behind it, and at once starts the exhaustion of the section of line which has just been traversed by the train. The valve of this relay has none of the objections attaching to that of the former relay, seeing that it opens of itself after the exhaustion of the section appertaining to the vacuum relay has been completed, an operation which is generally accomplished in half the time prescribed for the interval between the passage of two trains. Moreover, as these relays are placed every five kilometers, and at least one half of them are in places provided for compressing and exhausting the air, they are under the eyes of the attendants. The pressure relays placed one kilometer apart become simple blowers, opening on the passage of a train, and blowing all the time the train is traversing the section; they merely consist of a piston pushing a counter-weight acting upon a slide, which is the pressure slide, and the regulating piston which stops the admission of air after the blowing has lasted the proper time; the compressed air enters the line by a kind of grating which uncovers openings having twice the sections of the line, and the blowing is governed by the train itself which, acting upon a trigger, lets fall a counter-weight placed upon the piston working the slide. The blowing is instantaneous; it is stopped by the action of the regulating piston which closes the communication leading to the line, and shuts up the compressed air in a small chamber between the point where the communication is thus closed and the slide. The effect of this compressed air at the moment when the pressure is lost in the line, that is to say, at the moment when the train has passed through the section, is to raise the piston acting upon the slide, and to restore everything into position for the arrival of another train. This apparatus, which is the main feature of the new system, is extremely simple, and does not require personal supervision in its working. It is accompanied by a reservoir of compressed air of sufficient capacity for the section.

I need not here discuss in detail the means by which the compressed air and vacuum are to be brought to the reservoirs serving the relays. Any of the methods usually employed for this class of work can be made use of, but the most economical process would, of course, be selected. In a populous country the engine stations might be numerous, and the power employed small. In thinly inhabited countries they might be 20 or 25 kilometres apart, and the power would then have to be greater.

(To be continued.)

The First Idea of the Telegraphic Dial.—In a work written by Father John Laurechon, a Jesuit, printed in 1624, at Pont-à-Eousson, under the title of "Récréation Mathématique composée de plusieurs problèmes plaisants et facétieux," there is to be found a curious passage, well deserving to be quoted:—"It is stated, that by means of a magnet, or any stone of the kind of loadstones, absent persons could communicate with each other; for example, Claudius being in Paris, and John in Rome, if each had a needle rubbed with some stone having the power, as one needle should move in Paris the other could move correspondingly at Rome; Claudius and John could have similar alphabets, and having arranged to communicate at a fixed time every day, when the needle had run three times and a-half round the dial, this would be the signal that Claudius wished to speak to John and to no other. And supposing that Claudius wants to tell John that 'the King is at Paris,' he would move the needle to the letters *t*, *h*, *e*, and so on. The needle of John agreeing with that of Claudius would, of course, move and stop at the same letters, and by such means they could easily understand and correspond with each other. This is a fine invention, but I do not believe there is in the world a loadstone having such a power, and besides it would not be expedient, as then treason would be too frequent and too secret." Father Laurechon used to write under the assumed name of H. Van Etten. Annexed to the passage quoted, there is a diagram of a dial, with the 24 letters, having the needle fixed at the letter A. A similar allusion is to be found in the Dialogues of Galileo.

The Telegraph in New York.—The business of private telegraphing has reached to a wonderful extent in New York. The Western Union Company has 86 offices in the city, 70 miles of lines of telegraph poles, and 1,197 miles of wire. The Franklin Telegraph Company has 20 miles of poles, with 150 miles of wire; and the Atlantic and Pacific Company has 12 miles of poles, with 90 miles of wire. There are besides the Gold and Stock Telegraph Company and the Manhattan Quotation Company, which have together about 200 miles of single wires, besides a number of cable wires containing 11 wires bound together. These are suplemented by the wires of the Produce and Cotton Exchange Telegraph, Kiernan's "All News Telegraph," and several hundred of private lines belonging to merchants, brokers, bankers, steamship agents editors, &c. Even the lawyers now have private telegraph wires, so that without leaving their chambers they learn what is going on at the courts.—*Evening Standard.*

To Correspondents.

⁂ Duly authenticated contributions, theoretical and practical, on every subject identified with the interests of which "The Telegraphic Journal" is the organ, will always command attention. Anonymous correspondence will be wholly disregarded. Literary communications and books for review should be addressed to the Editor; business communications to the Publishers, 10, Paternoster Row, E.C.

THE TELEGRAPHIC JOURNAL.

Vol. III.—No. 63.

THE INTERNATIONAL TELEGRAPHIC CONFERENCE OF ST. PETERSBURG.

The telegraphic relations of the United Kingdom with the Continent are carried on under the provisions of a Convention concluded originally at Paris in 1865 between many of the principal States of Europe; adhered to afterwards by other States, by British India and Persia, and subsequently revised in 1868 at Vienna, and in 1870-71 at Rome. After the transfer of the telegraphs to the Government in 1870, the British Postal Telegraph Department decided to adhere to the International Convention, and was represented at Rome by Mr. Alan Chambre—who also, jointly with Mr. H. C. Fischer, represented the Department recently at St. Petersburg.

One of the chief objects of the International Telegraphic Conference of St. Petersburg was to consider a new codification of the Convention and Detailed Regulations which, by a decision arrived at at Rome, had been undertaken by the Bureau International at Berne. This work—admirably performed by the latter—resulted in a reduction of the Convention from 65 articles to 21, and this was achieved by transferring to the detailed regulations many provisions that previously formed articles of the Convention. The latter being considered to settle fixed principles and to be made once for all and unchangeable at the periodical Conferences, the wisdom of placing all questions and matters which can more properly be settled by regulations, will be apparent. The Detailed Regulations can, of course, be altered as experience and circumstances may, from time to time, show to be necessary or desirable.

To meet the views of several Delegates, the new Convention provides that periodical Conferences shall in future not be held successively in the capital of each of the contracting States as formerly arranged, but that each Conference shall settle the place and date for the next reunion.

The Conference held its sittings at the Ministry of the Interior. The countries represented at the opening sitting—which took place on the 1st June—were Great Britain, Austria, Hungary, Belgium, Denmark, Egypt, France, Germany, Greece, Italy, Japan, Norway, The Netherlands, Portugal, Russia, Sweden, Switzerland, and Turkey; and, subsequently, the Persian Government named a representative, and the Chargé d'Affaires of the United States attended the debates on behalf of his Government but took no part in the discussions, as the United States have not joined the Convention. The leading Cable Companies were also represented. His Excellency the Minister of the Interior, M. de Timatcheff, opened the Conference in a speech of welcome, and sketched out the programme of the labors about to be undertaken, with a view to building upon the experience of the past a more perfect and complete Convention regulating the International Code of Telegraphy. After a suitable reply made by the President of the last preceding Conference—that of Rome—the President-Elect of the St. Petersburg Conference, the Director-General of Telegraphs de Lüders, addressed the Delegates, and proceeded to name the staff for the Bureau of the Presidency.

The second meeting—and the first for practical business—was held on the following day, and afterwards the Conference met three days a week; leaving the other three working days free for the Commissions. The latter—No. 1 for questions relating to tariffs, and No. 2 for questions relating to rules and regulations—were very fully occupied in sifting the various propositions before their discussion in general Conference, and in this manner many propositions were withdrawn, modified, or amalgamated with rival proposals, and a large amount of valuable time was saved. This mode of procedure was much facilitated by the arrangement adopted under which both Commissions sat at varying hours, and the members of each were thus enabled to attend the sittings of the other Commission; but as Sub-Commissions had, later on, to be appointed, and the same principle was adopted, the effect was, practically, to make the work on these off days press very heavily upon the delegates. Any other arrangement would, however, have prolonged the Conference much beyond the time actually occupied—nearly eight weeks.

The New Convention remains to be ratified by the respective governments after consideration and signature by their respective Diplomatic Agents at St. Petersburg. The Delegates, on this occasion, signed the Detailed Regulations, but not the Convention as remodelled.

The printed *Procès-Verbaux* of the Conference, to a perusal of which we are indebted for our information, enable us to give the following outline of the leading questions discussed.

To suit the national prejudice and habits it was agreed, at the request of Great Britain, that each State may limit the hours of service *on Sunday* at offices which are not open permanently day and night.

The system in vogue in this country of allowing an abbreviated or code address for telegrams, upon the payment by the addressee of an annual fee, will be adopted, and the signature of the sender will no longer be compulsory.

All indications, such as "reply paid," &c., must in future be written by the sender in French; in the language of the country in which the telegram is to be delivered; or they may be given by letters adopted for the International Service, such as "R.P." &c.

The address, except the name, must also be given in French, or the language of the country to which the telegram is addressed.

The length of a telegram, except in the case of extra European traffic, will be maintained at twenty words, increasing by series of ten words as heretofore. A vigorous effort was made by Great Britain to obtain that a first decision of the Conference to adopt a gradation by series of *five* words should be maintained, but we regret to say without success. For Extra-European telegrams, the rate will be by word throughout the whole distance, but it will remain for the Administrations interested to declare for a simple word as in the case of Anglo-American messages, or for a word tariff with a minimum of ten words.

The maximum length of a word will be limited to fifteen characters of the Morse Alphabet, and

any word used in a telegram containing more than this number will be charged extra in proportion to the excess. In the case of Extra-European messages the same regulations will be made to apply, but with a limitation of *ten* characters.

In messages containing secret language (so-called), groups of ciphers or letters will be counted and charged for, group by group, in the same way as ordinary numbers written in cipher; that is to say, at the rate of one word for every five ciphers, any fraction over being counted as one word.

Three new classes of messages were introduced, and gave rise to prolonged and serious debates. Great Britain in common with Austro-Hungary in one case, with Italy in the second, and with Switzerland in the third case, declared that she was not prepared, for the present at all events, to adopt either one or the other, and in consequence of the formal opposition of several States in regard to these three measures, it was finally carried that they should be adopted only between such States as declared that they were willing to do so. These new messages consist of:—

First.— "Urgent" telegrams which are to have precedence over ordinary telegrams deposited at the same time, or earlier, and still awaiting their turn for transmission, and such telegrams are to be charged three times the ordinary rate.

Secondly.—The "*Telegramme recommandée*" with repetition, a receipt, and an acknowledgment, upon payment of a triple rate by the sender. In case of serious error or delay, or total loss of the message, the sender may claim not only to have refunded the rate paid, but is to receive a fixed indemnity of fifty francs."

Thirdly.—The "*Avis Telegraphique.*" This is declared not to be a telegram properly so called, but to give the facility to those persons who desire to send short messages at a cheaper rate the means of doing so, provided they are willing to forego all the advantages offered or to be claimed in the case of ordinary messages at the higher rate. They are to be limited to ten words, and must not contain secret or code language; numbers will only be accepted if written in full letters; they will be charged at the rate of three-fifths of the ordinary telegram, and will be delivered open (without envelope) to the addressee. No claims of any kind in respect of these messages will be entertained, and they will be transmitted between the offices admitting them without any of the formula observed in the case of ordinary messages.

A great many other changes and additions were made to existing regulations, either in elucidation or to remedy difficulties and objections which experience had shown to exist; but they are not of a nature to interest the general public.

One other measure of interest, however, was the passing of a resolution to adopt generally, wherever any of the States found it desirable to do so, the arrangement made between the British and French Administrations with the proprietors of the *Times* to allocate to the use of the latter, at night, for a yearly payment, in one sum, a wire between London and Paris, under which arrangement we are enabled—at our breakfast table—to read a column or more of news from the "most fascinating capital in Europe" up to the latest possible date.

The next Conference is to be held at London in 1878; but the exact date will be fixed by the British Government. Mr. Chambre, in announcing to his colleagues that Great Britain accepted the choice of the Conference, assured them that they would be welcome. Let us hope that our Government will indeed, when the time comes, show themselves to be alive to the necessity of receiving the representatives of every State in Europe, and several *out* of it, in a fitting and cordial manner and, without attempting to rival or excel the efforts of our Foreign friends to entertain the Conference, that they will not allow red tape and prejudice to stand in the way of doing what we can to make the sojourn of our numerous guests profitable and agreeable to them.

ON THE TELEGRAPHIC PROBLEMS OF DOUBLE SENDING AND QUADRUPLEX TELEGRAPHY.

By G. K. WINTER,
Telegraph Engineer to the Madras Railway.

The practical success which has attended the revival of duplex telegraphy has doubtless led many, besides myself, to enquire whether the difficulties in the way of the simultaneous transmission of two messages in the same direction over the same line were altogether insurmountable. A very little thought over the matter will show that the difficulties to be encountered in solving this problem are altogether of a different nature from those attending the question of duplex working, and, further, it is evident that if once these difficulties were overcome, the problem of quadruplex telegraphy would be solved by applying to our apparatus similar arrangements to those by which duplex telegraphy has already been rendered practical.

It is obvious that to send two messages at the same time in the same direction on the same wire between two stations, two keys are required, and it is also obvious that with two keys, each having independently two positions, there are four combinations, which of course should each produce a different effect upon the receiving instruments at the distant end. Thus, suppose we have two keys, which we will call A and B respectively, we shall have,

1st combination, both keys at rest.
2nd ,, A depressed, and B at rest.
3rd ,, B depressed, and A at rest.
4th ,, Both keys depressed.

There are two different ways of attacking the problem, namely:—

1st. To devise such an arrangement of the keys that each of the four combinations shall produce a different electrical effect on the line, and then to endeavour so to arrange the receiving instruments that these different electrical effects shall be rightly interpreted by them.

2nd. To endeavour so to arrange the receiving instruments that, with some four variations in the electrical state of the line, four combinations, analogous to those of the keys we have noticed above, may be produced; and then to devise some arrangement of the keys by which the desired electrical states of the line may be produced by their action.

I have only seen two systems described in any of

the works on electricity or telegraphy that I have read. One is given by Blavier, and the other by Sabine. In each of these it would appear that the inventors had set to work according to the first method, for in each the method of joining up the keys is practically the same, and intended to produce currents as follows:—

1st. Both keys at rest. No current.
2nd. A depressed, and B at rest, one unit of current.
3rd. B depressed, and A at rest, two units of current.
4th. Both keys depressed, three units of current.

All the currents being in the same direction.

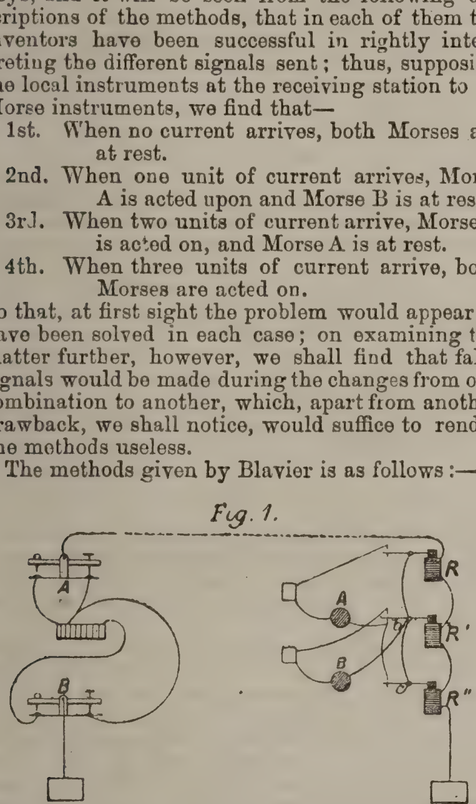
This is the most obvious arrangement of the keys, and it will be seen from the following descriptions of the methods, that in each of them the inventors have been successful in rightly interpreting the different signals sent; thus, supposing the local instruments at the receiving station to be Morse instruments, we find that—

1st. When no current arrives, both Morses are at rest.
2nd. When one unit of current arrives, Morse A is acted upon and Morse B is at rest.
3rd. When two units of current arrive, Morse B is acted on, and Morse A is at rest.
4th. When three units of current arrive, both Morses are acted on.

So that, at first sight the problem would appear to have been solved in each case; on examining the matter further, however, we shall find that false signals would be made during the changes from one combination to another, which, apart from another drawback, we shall notice, would suffice to render the methods useless.

The methods given by Blavier is as follows:—

Fig. 1.



R R' R'' (Fig. 1) are three relays joined up one after another between the line and the earth at the receiving station.

Of these R is the most sensitive and will work with one unit of current.

R' is rendered less sensitive by means of an opposing spring: it will not work with one unit of current, but it will with two.

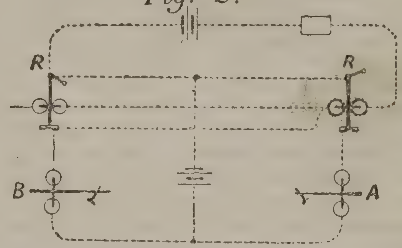
R'' is rendered still less sensitive by meaas of stronger opposing spring; it will not work with less than three units of current.

It will be seen that the Morse A is joined up in such a way that so long as the relay R' is at rest, it will work whenever the tongue of relay R is acted upon by the current. So long, therefore, as the key A only is worked, and, consequently, only one unit of current sent into the line, the Morse A will indicate the signals given by the key A. When the key B is depressed, it is evident that two units of current are sent into the line, consequently, the current is strong enough to work both the relays R and R'. The relay R' in working, completes the circuit of Morse B, and at the same time breaks the circuit of Morse A; thus, so long as only the key B is worked, the Morse B will indicate the signals given by the key B. Now suppose we depress both keys, there will be three units of currents, and, consequently, the relay R'' will be worked as well as the others. It will be seen that when relay R'' is worked, the break in the circuit of Morse A, which is caused by the working of relay R', is made good, and thus both Morses will be woaked. So far, all well; but now let the key B be raised, the current will be reduced to one unit, and, consequently, both the selays R' and R'' will be drawn back. Of course the circuit of Morse B will be broken, but so also will, for an instant, that of Morse A; for it is evident that the tongue of relay R'' will have broken contact with C before the tongue of relay R' can have made contact with B, and thus recompleted the circuit of Morse A. Thus, at this change, there will be a sudden interruption of the working of Morse A, not answering to any signal given by its key, and a confusion of signals must arise.

Added to this, however, the difficulty of keeping the three relays at proper states of sensitiveness would be almost insurmountable. The difficulty of the interruptions of the circuit in the intervals between the positions of rest and the depression of the keys could be overcome by known methods.

The system given by Sabine was invented by Stark, of Vienna, in 1855. The method of connecting the keys was somewhat different from that shown above, but the result was exactly the same, so we will only concern ourselves with the receiving apparatus. This is represented in Fig. 2.

Fig. 2.



In this arrangement only two relays of different degrees of sensitiveness are employed. Relay R is the most sensitive, and will work with with one unit of current; relay R' is less sensitive, and will work with two units of current, but not with one. When relay R' works, however, it not only completes the circuit of the Morse B, but also of another circuit, through an extra coil of the relay R, in such a direction as to oppose the action of the currents coming from the line, and thus render it less sensitive and only to be worked by three units of current in the line circuit.

According to the plan, whenever the key B is worked both relays will work for it is not until the relay R' has made its contact that the sensitiveness of relay R will be reduced, consequently at every depression of the key B we shall have a momentary kick on the Morse A, not in accordance with any signal given by its key, and thus confusion of signals must result Again, although we have only two

relays to adjust as to sensitiveness, yet one of these has two states of sensitiveness, one of which, namely, that caused by the opposing action of the local current, would be even more troublesome than the adjustment of the third relay by means of a spring. Neither of these methods can therefore be said to offer any hope of practical success.

Having now examined the principles and learnt the defects of the old systems, I will next endeavour to explain as clearly as possible the principles of the system by which I have achieved a practical success, and the line of thought which led to its discovery.

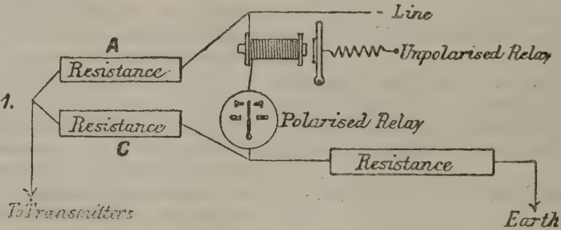
(To be continued.)

QUADRUPLEX TELEGRAPHY.

By A. EDEN, Assoc. Soc. T. E.

The *Telegraphic Journal* of the 1st ultimo contains a paper read before the meeting of the American Electrical Society at Chicago, U. S., by Mr. F. W. Jones, which describes Messrs. Prescott and Edison's "Quadruplex" as a "Wheatstone's Bridge," in which two relays are placed in the position of the Galvanometer, thus:—

Fig 1.



One of the chief objections urged against duplex working on the Bridge method is the fact that the resistances forming the arms A to C act as a shunt for the received current, a current, it may be remarked, which is already weakened by division between the line and the artificial line at the originating station, and also by any leakage which may occur during transit through the line-wire.

This is referred to by Mr. Jones, who seems to attribute the low percentage of effective current (as compared with the Differential duplex) to this cause.

It occurred to me, however, that if one of the receiving instruments could itself be made the arms of the "Bridge," and the other receiving instrument inserted in the Bridge wire, that one of the derivations from the effective received current would be avoided, and intead of losing the current passing by the arms A and C, it would be available for signalling purposes.

Putting this view of the question to a practical test, when I could spare time from official duties, I found that it answered admirably, but that some difficulty was experienced with the unpolarised receiving instrument.

This was eventually overcome, and one of the advantages of this mode of connection seems to be a practical exemption from the induced-current difficulties mentioned by Mr. Jones as being incidental to the American method.

The resistances A and C (Fig. 2) forming the arms of the bridge, are the two coils of, a differential polarised relay through which the outgoing currents pass in opposite directions, the current

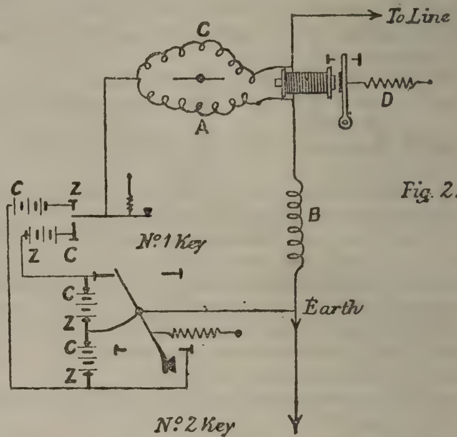


Fig. 2.

passing by A, going through the resistance marked B, and that going *via* C passing out to the line.

No. 1 key is arranged to send reversed currents, which actuate the relay A C of the distant station. No. 2 key puts into, or takes out of circuit a certain amount of extra "battery power," which brings the unpolarised relay D into action, at the distant station.

The actual key connections cannot be conveniently shown, and the arrangement sketched in the figure would be very clumsy in practice.

Practically, two sets of batteries are not required to produce reversals, and special arrangements prevent any interruption by the insertion or withdrawal of the extra force by No. 2 key, any irregularity in the received signals on D, owing to the changes of polarity in the received current produced by the distant stations No. 1 key, or any alteration of the battery resistance when No. 2 key is closed or opened.

Subsequent experiments proved that the best method is to make A a resistance equal to the ininstrument coil in C, and put the other instrument coil behind the adjusting resistance B, and the point of junction between A and the Bridge wire.

LONDON FIRES—WATER SUPPLY.

Not long since our contemporary the *Standard*, in a powerful leading article, directed attention to a communication addressed to it by the East London Waterworks Company with reference to the above important subject. From this communication it

appeared that a letter had been received by the company from the Metropolitan Board of Works, stating that the attention of the Fire Brigade Committee had been called by complaints and inquiries from local boards and others "to the delays "which, even with the best efforts on the part of "the water companies, occasionally occur in "obtaining a supply of water at fires." The committee were said to be "well aware that the only certain way of avoiding these delays, and of being always sure of an immediate supply of water available for extinguishing fires, was to have all the mains constantly charged at high pressure." But as this was not at the present moment, and probably would not for some time be obtainable, the committee were anxious to ascertain whether "some means might not be found by which the men of the Fire Brigade would be able, on arriving at a fire, to obtain immediately for themselves a supply of water without waiting for a turncock in the event of the latter not being at a fire so soon as themselves."

From the foregoing and from other portions of the correspondence between the Metropolitan Board of Works and the Waterworks Company, it would appear that a difficulty is at times felt in obtaining, in certain localities, a ready and efficient supply of water, to enable the London Fire Brigade to cope with that element which once destroyed, and may again prove disastrous to, our capital.

Many parts of London are already supplied with water under pressure night and day, Sundays and holidays; but many other portions—and doubtless these portions are those narrow, densely-populated thoroughfares in which fires are most difficult to deal with, and in which, where a fire once gets a hold from want of water or other causes, its ravages are terrible—are either entirely without a water supply, or have only a short "service." The Board of Works points out that although each fire-engine carries with it a complete set of turncock's tools, it is not unfrequently found of no avail, inasmuch as the firemen do not know what mains in the neighbourhood of the fire are charged with water at the time.

Will not the Postal Telegraph Department, or some energetic telegraph engineer, step forward, and, whilst relieving both the Board of Works and the Water Companies of their difficulty, contribute towards the greater security of life and property in the Metropolis, by suggesting the propriety of establishing electric communication between the district police or fire stations, and the officer whose duty it is to see to the turncocks of that locality?

Nothing could be easier than to establish some such simple means of communication as should obtain attention at any moment, night or day. Bells of almost any tone and power are now under the control of the telegraph engineer, whilst, if necessary, indicators carrying the name of the locality or street could at will, and at the same time as the bell is ringing, be brought up to an aperture; there would be thus not only an audible, but a visual signal to those in charge. Wherever it is usual for the turncock to be sought in the moment of need by the fireman, whether at an office, or at his residence, this bell indicator ought to be fixed; the wires from the different fire-engine stations in the section under his charge would concentrate upon that point, and on either one being used the "indicator" would show, independent of the bell, the locality where the man's services were required. By this means a certain, and in all probability a very great advantage in point of time would be gained, and we all know what this means in a question of fire.

With such means at our command—simple and uncostly—surely it is not expedient that valuable property, apart from the sad loss of life that too frequently accompanies it, should longer remain subject to the present uncertain method of obtaining the services of the all-important "turncock." Doubtless hydrants and mains constantly charged under pressure would, with certain regulations, render the most efficient aid; but as this is not yet, and cannot for some time be obtainable, if indeed it ever will be in certain localities, then let us by all means have the best substitute for it. As to the protest of the Waterworks Company—"That "it is not their duty to bear the expense incident "to maintaining the present slovenly and imper"fect practice, and that they ought not to be "subjected to the aggravated waste which is "necessarily incident to it," we are only doing ourselves justice in pointing out that the course we suggest to the consideration of both bodies is one calculated to remove at once any source of waste, whilst the expense which will be incurred by adopting it is so trifling that the fire insurance offices themselves would doubtless gladly defray it, and save money by the transaction.

THE BRITISH ASSOCIATION.

THE great carnival of science, the meeting of the British Association, was opened at Bristol, on Wednesday, August 25th, by Sir John Hawkshaw, the President for the present year, delivering his inaugural address. As intimated by Professor Tyndal, the retiring President, in a few brief words of introduction, Sir John wholly avoided all controversial and speculative subjects and theories, and confined himself entirely to a lengthened review of Engineering Science (of which he is one of the greatest living ornaments), in its broadest aspect, from the early ages of the world to the present time. No attempt was even made to foreshadow the future triumphs of engineering skill, the past and present only being dealt with. Telegraphy naturally came in for a share of the President's remarks, but little was added to the chronology of this branch of engineering beyond what had previously appeared in the address of the President of the Society of Telegraph Engineers. The following statistics given by Sir John may, however, here be quoted. "The first useful telegraph was constructed upon the Blackwall Railway in 1838, Messrs. Wheatstone's and Cooke's instruments being employed. From that time to this the progress of the electric telegraph has been so rapid, that at the present time, including land lines and submarine cables, there are in use in different parts of the world not less than 400,000 miles of telegraph . . . . . The telegraphic system of the world comprises almost a complete girdle round the earth; and it is probable the missing link will be supplied by a cable between San Francisco in California and Yokohama in Japan. How resolute and courageous those engaged in submarine telegraphy have been will

appear from the fact that, though we have now 50,000 miles of cable in use to get this result, nearly 70,000 miles were constructed and laid."

On the following day the sectional meetings were opened by the Presidents of Sections delivering their addresses, and then commenced the labours of this extraordinary body, which travels over such an immense range of subjects, that, like the elephant's trunk, which with the same ease picks up a pin or tears down an oak, it is equally prepared to discuss the construction of the channel tunnel, or the use of "lady-helps," to trace back the origin of man to the first form of life, or to consider the construction of a new sewer trap.

It may not be inappropriate here, for the information of those who are unacquainted with the working of the association, to state that it was founded in 1831, by Sir David Brewster, who in that year arranged a meeting of the leading scientific men of the day, to be held at York. Here papers were read, models were exhibited, and other steps taken for the permanent advancement of science in the kingdom. Three years later the system of establishing committees, with special grants of money, for the investigation of definite questions was started, and this has been followed up most successfully in succeeding years, questions of importance in all branches of science being dealt with. Telegraphists especially have great reason to be thankful to the British Association, for the labours of that committee which reported on and defined the units of electrical measurement, which have now with such advantage been wholly adopted in this country.

For convenience of working, the meetings are divided into six sections, viz., Mathematical and Physical Science, Chemical Science, Geology, Biology, Geography, Economic Science, and Mechanical Science, and papers on each of these subjects are read and discussed during the meetings.

Comparatively few on electrical or telegraphic subjects have been contributed this year, and none of these would bear satisfactory condensation here. The address of Professor Balfour Stewart, the President of the Mathematical and Physical Section, however, contains the following remarks, which will be read with interest:—

"We are aware that the earth is a magnet. Let us not now concern ourselves about the origin of its magnetism, but rather let us take it as it is. We must next bear in mind that rarefied air is a good conductor of electricity; indeed, according to recent experiments, an extremly good conductor. The return trades that pass above from the hotter equatorial regions to the poles of cold, consisting of moist rarefied air, are therefore to be regarded in the light of good conductors crossing lines of magnetic force; we may therefore expect them to be the vehicle of electric currents. Such electric currents will of course react on the magnetism of the earth. Now, since the velocity of these upper currents has a daily variation, their influence as exhibited at any place upon the magnetism of the earth may be expected to have a daily variation also. The question thus arises. Have we possibly here a cause which may account for the well-known daily magnetic variation? Are the peculiarities of this variation such as to correspond to those which might be expected to belong to such electric currents? I think it may be said that as far as we can judge there is a likeness of this kind between the two peculiarities of these two things, but a more prolonged scrutiny will of course be essential before we can be absolutely certain that such currents are fitted to produce the daily variations of the earth's magnetism. Besides the daily and yearly periodic changes in these upper convection currents, we should also expect occasional and abrupt changes forming the counterparts of those disturbances in the lower strata with which we are familiar. And these may be expected in like manner to produce non-periodic occasional disturbances of the magnetism of the earth. Now it is well known that such disturbances do occur, and further that they are most frequent in those years when cyclones are most frequent, that is to say in years of maximum sunspots. In one word, it appears to be a tenable hypothesis to attribute at least the most prominent magnetic changes to atmospheric motions taking place in the upper regions of the atmosphere where each moving stratum of air becomes a conductor moving across lines of magnetic force; and it was Sir Wm. Thomson, I believe, who first suggested that the motion of conductors across the lines of the earth's magnetic force must be taken into account in any attempted explanation of terrestrial magnetism. It thus seems possible that the excessive magnetic disturbances which take place in years of maximum sunspots may not be directly caused by any solar action, but may rather be due to the excessive meteorological disturbances which are likewise characteristic of such years. On the other hand, that magnetic and meteorological influence which Mr. Broun has found to be connected with the sun's rotation points to some unknown direct effect produced by our luminary, even if we imagine that the magnetic part of it is caused by the meterological."

In addition to the general work of the meeting three special lectures were given. These were, by Mr. Spottiswoode, on the "Colours of Polarized Light"; by Dr. Carpenter, on "A Piece of Limestone"; and by Mr. Bramwell, on "Safety Appliances for Railways." In the latter the lecturer dwelt at length in a very able manner on all the mechanical improvements which have within the last few years been introduced in railway working, and he gave satisfactory and conclusive figures showing the beneficial effect of these, but curiously enough whilst dwelling on the necessity for the block sytem of working heavy traffic, which really compelled the adoption of most of these improvements, he omitted all mention of those numerous electrical appliances, without which the block system in itself could not be carried out for any but the shortest sections.

Two soirees were given during the meeting, the first being wholly devoted to microscopy, the second to general subjects. A large display of telegraphic apparatus was made by the Post Office on the second evening, automatic, duplex, ink writing, sounders and needle instruments, being in direct communication with Manchester, London, Exeter, and Paris, in addition to local circuits across the room. The earliest practical instrument, the five-wire needle, used between London and Slough, and the latest invention, the electro-motograph, were likewise exhibited, side by side. Telegraphic apparatus appears to afford an un-

ceasing subject of interest, on all occasions, when freely exhibited and explained to the general public; even savants who are thoroughly acquainted with all theoretical details, will crowd around to examine the practical working. A constant stream of communications was maintained the whole evening, especially with Paris, from which place information of all kinds was in constant demand. Amongst other matters, as a tribute to an Englishman's pluck, the reply was received in answer to a question as to what was thought of Captain Webb, that he was "*un homme de fer.*"

A magnificent display of vacuum tubes was exhibited by Mr. F. J. Fry, of Bristol, a gentleman who has, perhaps, the largest display of these splendid philosophical toys in the kingdom. Clamond's new thermopile was likewise exhibited in full action, working a small induction coil. This instrument, which has been fully described in this journal, is the most satisfactory solution that has yet been offered of the problem of converting heat directly into electricity in a practical form.

The work of the meeting was finally closed on Wednesday, the 2nd inst., by the holding of a General Committee, when, amongst other matters, grants of money were made for the continued investigation of "Thermo-electricity," and for "Testing the exactness of Ohm's laws."

ON A SYSTEM OF TELEGRAPHY.

A Course of Lectures, delivered at the School of Military Engineering, Chatham,

By W. H. PREECE, Member Inst. C.E., &c.

Lecture I.—A System of Telegraphy as applied to Railway Purposes.

(Continued from page 195.)

One of the most recent improvements, the latest finishing touch, has been to make these signals both by day and by night repeat themselves back to the man who manipulates them, so that the distance and situation of the signal post are to him no longer a matter of consequence. It may be three-quarters of a mile away around a curve hidden by a wood or fixed the other side of a tunnel; indeed, wherever it may be, this faithful tell-tale informs him of its condition.

The line from Southampton to Dorchester was opened in 1847. It was a single line. Trains upon it were also very few, but though few, it almost invariably happened, through the length of the line, that two trains running in opposite directions were on different points of the line at the same time. These trains must necessarily have met and passed each other somewhere. To make them meet and cross without colliding was the first problem to be solved. Meeting stations were appointed where trains were timed to arrive at the same time, and where the first train that arrived had to wait till the second one came. It frequently occurred that the one train was delayed from breaks-down, excessive traffic, and various other causes. The officials at the meeting places were utterly ignorant of the cause—delays became excessive—hence arose one of the first practical requirements for the telegraph. Information was wanted of the position and progress of the trains. A double needle telegraph, similar to that which had been already erected for governmental, experimental, and commercial purposes, between London and Gosport in 1844, was now erected on the Southampton and Dorchester line purely for expediting railway travelling. Intimation of the position of every train was telegraphed from station to station. Three wires were erected, two of which were used for a double needle telegraph with an instrument fixed at each station. To the third wire a bell was attached at each instrument to call attention when needed, but the bell speedily proved a nuisance, for when any one station was required every bell throughout the line was rung, and it was abandoned. A superintendent was constantly travelling up and down the line. When he found by telegraph that one train was late, he would give orders to stop it at a preceding station and take on the other train himself. It was afterwards found that he could best control the traffic from one fixed station in the centre of the line, and change the meeting places of trains from his own office. A very long length of single line was opened in 1860 from Basingstoke to Exeter. The system of the Dorchester Line was too crude. It was much elaborated and improved, and I attach as an appendix to this lecture the full rules and regulations on the subject; the principle however was the same. Superintendents were appointed over separate sections of the line, one from Basingstoke to Salisbury, another from Salisbury to Yeovil, a third from Yeovil to Exeter. Each of these superintendents was informed by telegraph of the movements of every train. When he found they were running irregularly, he would stop one train, move on another, change their meeting places, and so adjust the movements of the traffic that the regularity with which the trains were moved was surprising; the traffic however became too heavy and important for a single line, and the line was eventually doubled throughout. The direct Portsmouth line from Guildford to Portsmouth which was opened in 1859, and the North Devon Line from Exeter to Bideford, which passed into the South Western system in 1862, are still single lines, and the traffic upon them is regulated upon this method. Even on a double line, single line working at times becomes necessary when accidents occur, as for instance, a train may break down and block up one road. A portion of the road itself may be rendered impassable by some accident, or it may be destroyed by an enemy, and only one road may be got ready. A well organized system of working, aided by the telegraph, can then transport the maximum traffic with the minimum danger.

It is in fact the only method which admits of the transference of irregular and large traffic upon a railway of a single set of rails. Additional means for securing safety such as the staff or the block system may be added, but the adjustment of the traffic can only be effected by the telegraph, and the telegraph therefore is an essential feature of a railway.

The staff is a truncheon or ticket, which is attached to each section of a railway, and without which no engine must move, so that between A and B no train or engine can stir without its staff.

When, however, more than one train is required

to run in the same direction the first train carries a ticket only, the last train always taking the staff, the ticket and staff belonging to each other, and the ticket not being used without the staff being seen by the driver. Hence collision is impossible if this system be rigidly carried out, but delays arising from its use are frequenlly excessive, and I have known cases where a man and horse have been sent to fetch a staff to take on a train. Indeed the train staff is wholly inapplicable to any railway upon which the traffic is large.

The block system arose out of the multiplication of trains and the necessity for increased speed. Necessity, the mother of invention, brought it into existence. The block system is that system by which trains are kept apart upon the same line of rails by a certain and invariable interval of *space*, instead of by an uncertain and variable interval of *time*. The term Block is an unfortunate selection. It was introduced through the practice of "blocking" or pinning the telegraph needle over in the earliest instruments used to work the system. The "space" system in opposition to that of "time" would have been more accurate; but the word "block" has now become so thoroughly rooted in railway language that it would be difficult to supplant it.

The practice under the time system is to exhibit the danger signal for five minutes, and the caution signal for five minutes more, after a train or engine has been despatched from or passed any station, junction, level crossing, or siding. Trains are thus said to be kept apart by fixed periods of five minutes, and if the caution signals were properly regarded, by an interval of time even longer than that. The safety of the train is entirely the responsibility of the driver. Immunity from accident is dependent upon his keeping a clear look out. If engines ran at regular and fixed speeds, if time tables could be adhered to, if the line be not crowded with traffic, if the driver could always ensure a good view before him, if signals were near together and they were properly regarded, then a rigid interval of time might be maintained between following trains; but none of these elements of safety are constant. Fast expresses follow slow goods trains, now through a thick fog, now up a wet incline, at one moment in bright sunshine, at the next in a thick snowstorm, creeping mineral trains break down in a long interval between two stations, passengers rush in at the very last minute, detain the train, and prevent the time tables from being adhered to, trains are so frequent at some places that the five minutes interval cannot be adhered to, obstructions to view arise from curves or cuttings, or from atmospheric causes, long lengths of line are unprotected by any signal at all, and signals themselves are too frequently neglected. Hence, the system is brimful of elements of danger, and the inexorable logic of facts has shown that the time interval is illusory and the system unsafe.

But when trains, however rapidly or slowly they may be running, however much punctuality has been infringed, however crowded with traffic the line may be, are invariably kept apart by an interval of one or two miles, collision between them becomes impossible. This is the *Block system*, which has, very improperly, been divided into two classes—the *absolute* and the *permissive*. The former is the block system proper, the latter is not a "block" system at all, but a system introduced by the London and North Western Railway Company at the suggestion of Mr. Edwin Clark, not to secure the safety of their trains, but to increase the capacity of their line for the transmission of their enormously increasing traffic. It is, doubtless, an improvement on the time system, but it bears little affinity to the block, and should certainly not be included in the same category.

I wish to draw a broad distinction between the block system as an abstract principle, and the means of carrying out that principle. The two are very much confused. We hear of Tyer's, of Walker's, of Spagnoletti's, and of other block systems. They are not block systems; they are simply instruments devised to carry out the electrical portion of the block principle.

The block system can be carried out by any system of telegraphy, nor is it even necessarily an electrical question, but practically it must become so, and any form of instrument which may be in use upon the railway can be converted into a means to work the system.

[The lecturer then exhibited the form of instrument employed in carrying out the block system upon the London and South Western Railway.]

The block system on single lines is additionally used to protect trains from *advancing* as well as from *succeeding* trains. Before a train is allowed to leave A the line at B is blocked in advance, and when it leaves it is blocked behind at A, so that it is thoroughly protected in both directions during the period it is running from A to B.

But apart from the protection which electricity imparts to railway travelling and the facility it offers for adjusting and regulating the traffic, there are innumerable purposes for which the telegraph is employed to facilitate business and to secure efficiency. The distribution of correct time, the collection of spare trucks and coaches, the relief of staff, the supply of assistance in cases of accident and danger, and—not least—the reparation of the error and thoughtlessness of passengers. In examining the messages at railway stations, an inquiry for the inevitable black bag is invariably seen, and I have also seen an inquiry for a pair of spectacles and a pig, an umbrella and the Bible, a purse and a barrel of oysters, a great coat and a baby.

But to return to our own immediate subject which must occupy the prime attention of the Commander, viz:—the employment of Railways in the time of war for the movement of troops, of the materials of war, of stores and of food; an inseparable and fundamental part of the organization of this service is the proper control regulation and management of the telegraph. It is not too much to say that the success of future operations of war will depend upon the rapidity with which trains are moved and upon the efficiency with which railway service is managed, and these are essentially the functions of the telegraph.

Catastrophes must, and will happen, but the element of accident pure and simple plays a very small part in railway catastrophes. The so called "accidents" are generally the result of carelessness of servants, economy in management, imperfect discipline, neglect of regulations or want of organization. I have endeavoured to sketch out to you what should be the organization of that portion of

railway working dependent upon a system of telegraphy; I give you a copy of the latest and most carefully corrected regulations for working double and single lines; discipline and management rest with yourselves, but where human agency exists we must be always liable to human error, and it is hopeless to expect that soldiers are more exempt from human frailties than those much abused railway servants who are employed in the regulation of the traffic upon our railway system.

I cannot conclude without paying a tribute of respect to those officers of the Royal Engineers who act as Inspecting Officers of the English railways to the Board of Trade. The reports of these officers upon accidents which occur are not only interesting as narratives, but instructive as to the different modes of working on different lines. They are the records of past experience. They favour the application of the law of average to bring out the defects or merits of variations in railway working. Dangerous modes of working are frequently carried on for long periods without accident, but inevitably they break down at last. The Board of Trade publishes these accidents, and brings to the knowledge of the many what would otherwise have been the experience of only the few. The lessons taught by experience are thus promulgated, discussion is invited, and the process of pure scientific reasoning applied. These reports of officers of the Royal Engineers furnish experimental data to form the basis of a true science—the science of railway working. If anyone desires to learn how to work a railway let him read these reports, if he wants to know how to construct and maintain a telegraph, let him read the lectures that have been delivered before, and the professional papers that have been published by the Corps. If he wants to know how to combine the two I trust I have sketched lightly, but I hope comprehensibly a system which has the merit of being created by that best of teachers—superior to all the theory of the universe—stern experience.

(To be continued.)

ELECTRICAL SCIENCE IN CHINA.

Last year, during the height of the excitement caused by the anticipations of war with Japan, the Imperial authorities gave directions to establish a college for the instruction of a staff of Chinese in the science of torpedo engineering.

An extensive building has been secured near the City of Foochow, admirably situated on the River Min; about forty students got together, and a large supply of the latest and most improved torpedo apparatus, manufactured by the Silvertown Telegraph Company, sent out. Some of the instruments are most beautiful specimens of the application of electrical science to modern submarine warfare; indeed the whole of the plant is identical with that at present used by our Royal Engineers at Chatham and elsewhere. The services of Mr. J. A. Betts, M.S.T.E., have been secured as Engineer-in-Chief. Mr. Betts was formerly in the torpedo department of the Silvertown Telegraph Company, and left England in October last.

The course of instruction will include the manufacture of torpedoes, mooring and placing them in position, the use of the "firing arcs" in torpedoes fired by observation, lime-light signalling, &c. A class will also be formed to receive instruction in practical telegraphy, testing, &c.

Active operations are being carried on at the arsenal, inside the city, for the manufacture of the mechanical parts necessary for the completion of a large stock of torpedoes; the electrical stores will of course be supplied from England.

What with the satisfactory arrangement of the dispute between the Chinese Government and the Great Northern Telegraph Company, concerning the Foochow-Amoy telegraph line (in which Mr. Betts acted as arbitrator for the Chinese Government), and the formation of a corps of Torpedo Engineers, China would seem to be advancing, whether for good or evil to foreign interests remains to be seen.

Notes.

Experiments with the electric light as a head light for locomotives have recently been made in Russia on the railroad from Moscow to Kursk with successful results. The apparatus consisted in a battery of 48 couples, which produced sufficient illumination to light up the track for a distance of from 1,500 feet to 1,800 feet ahead. A correspondent of *Les Mondes* suggests that a small electric machine would serve the purpose much better than a galvanic battery.

Telegraphic communication has been opened with Gladstone, in the northern agricultural districts of South Australia.

The number of telegrams despatched by the Great Northern Telegraph Company in the first seven months of this year, was 414,648, as compared with 458,134 in the corresponding period o 1874, showing a decrease this year of 43,486 telegrams. The revenue collected by the Company to July 31, this year, was £96,394, as compared with £99,469 in the corresponding period of 1874, showing a decrease of £3,075 this year.

Mr. George Robinson has patented a new process for sawing wood. The process, consists in substituting a platinum wire for the saw. The wire is heated to a white heat by the passage of an electric current. The wire, to which a forward and backward movement is given, cuts across the hardest woods with inconceivable ease. The platinum wire, constantly maintained at a white heat by the electric current, advances in the wood by carbonizing the surface which it touches, but this carbonization is entirely superficial and has no bad effect.

The directors of the Indo-European Telegraph Company, at their board meeting on the 7th instant, declared an interim dividend for the six

months ended 30th June last, at the rate of 5 per cent. per annum.

The S.S. *Caroline* has left for Whitehaven with the Isle of Man cable on board, and the restoration of communication may be expected at any moment. The cable is almost entirely new and of a heavier type than the former. It is to be hoped that it will be some years before there is any interruption again.

The Great Northern Telegraph Company's traffic receipts for the month of August amounted to 385,001 francs, as against 415,383 francs in the corresponding period of last year. The total traffic receipts from 1st January to 31st August amounted to 2,794,859 francs, as against 2,902,109 francs in the corresponding period of last year.

The Eastern Telegraph Company's traffic receipts for the month of August amounted to £30,005, against £31,265 in the corresponding period of 1874. The traffic receipts of the Eastern Extension, Australasia, and China Telegraph Company (Limited) for the same period amounted to £20 072, against £19,627 for the corresponding period of 1874; and those of the Brazilian Submarine Telegraph Company (Limited) to £10,032, against £9,761 last year.

The number of messages passing over the Cuba Submarine Telegraph Company's lines during the month of August was 2,272, estimated to produce £2,200, against 1,750 messages, producing £1,622, in the corresponding month of last year.

Information has been received by the Cuba Submarine Telegraph Company of the interruption of the Key West Punta Rassa cable belonging to the International Ocean Telegraph Company. Communication between those points is being maintained by steamer at a delay of about one day. Should the cable not be speedily repaired the new cable, which has arrived out but is waiting for more favourable weather, will be at once laid.

An official announcement has at length been made of the completion of the repairs of the Direct United States Cable. The insulation of the cable is reported by the contractors as being perfect:—"We understand that the tariff of the Direct United States Cable Company, whose cable, as announced, is finally in complete working order, and which will be opened for traffic on the 15th inst., has been settled as follows:—To Canada, by day, 1s. 10d.; by night, 1s. per word; to New York and the zone comprising New England and Pennsylvania, by day, 2s.; and by night, 1s. 2d.—the rates for the other zones into which the working on the American continent is divided being calculated on the same basis. The peculiarity of this tariff, it will be seen, is the distinction between day and night service, which is in reality a distinction between express and non-express messages, the former being charged a higher rate. The non-express messages, however, are not to be subject to any delay. The arrangement simply is that any person may put in a telegram at any hour of the day, marked *night* service, and it will be delivered next morning. As practically two-thirds of the messages transmitted are believed only to require delivery next morning, the tariff now established is for general purposes only 1s. 2d. a word, and fairly enough a higher charge is made where delivery before next morning is important. The reform of charging specially for express messages has often been urged upon telegraph companies, and the new competitor for Atlantic telegraph business does good service by introducing it, in addition to the benefit it confers on the public directly by lowering its general tariff. The Direct Company is thus fulfilling its pledges to make messages cheap, the public being also virtually indebted to it for having already, by the mere prospect of its competition, compelled the lowering of former high tariffs to the present rate of 2s. per word. We may express the hope that the policy thus initiated will be faithfully adhered to."—*Daily News.*

Not so many years ago it was considered a feat in deep-sea sounding to reach a mile or a mile and a half, and even then, after allowance has been made for the action of currents upon the line, the actual depth attained was a good deal matter of calculation or guess. Breakages also were continually occurring in the hauling up, from the necessary slenderness of the cord in comparison with the weight of the lead. The modern method by which the lead detaches itself at the bottom meets that as well as several other difficulties nearly as important, and the wonder is that it was not thought of sooner. Now there is scarcely any limit to the depth of soundings, except the depth of the sea, which the recent explorations of the Challenger go far to show to be in accordance with the theory that its greatest depth is equivalent to the height of the highest elevations above its level. The deepest sea soundings yet effected were obtained by the Challenger this year in the abysses off New Guinea, depths which have occasioned a sharp line of demarcation between the fauna of Asia and Australasia. The "lead" weighed 4 cwt., and struck bottom at the tremendous depth of 4,450 fathoms, or about 26,700 feet. The hollow rod, by which specimens of the bottom are brought up, was full of mud, and both the thermometers that had been sent down were smashed to atoms by the

enormous pressure of the superincumbent water. A previous unsuccessful attempt to reach the bottom, but in which 4,545 fathoms were sounded, showed the temperature at that depth to be 35½ deg. Fahr., uncorrected.

The traffic receipts of the Direct Spanish Telegraph Company for the month of August were £1,773, against £1,282 in the corresponding period of last year. From the same company we learn the average time occupied in the transmission of telegrams between Madrid and England, "*via* Santander," during August was three hours and four minutes (including transmission over Spanish land lines).

The half-yearly meeting of the proprietors of the Submarine Telegraph Company was held on August 24th, at the London Tavern, Bishopsgate-street, Sir James Carmichael in the chair. The report and accounts having been taken as read, the Chairman, in moving their adoption, said there was very little to which he need call the attention of the meeting. They were all aware of the Telegraphic Conference which had been held lately at St. Petersburg, and at which that company was efficiently represented by its secretary, Mr. Clare. He was happy to say that nothing occurred there which affected the interests of that company. Various resolutions were passed respecting international traffic, but none of them affected their interests. The delegates considered it not desirable to alter the rates for the general European traffic, and therefore they remained in *statu quo*. So far as his own opinion was concerned, he would have been glad to have seen a moderate general reduction of the rates, believing that such a reduction, if made prudently, always led to an increase of traffic, and encouraged the public to telegraph more than they had done; but, as he had first mentioned, the delegates of the different governments thought otherwise. He regretted that the receipts of the last half-year were not a little larger, but it must be remembered that that was always the worst half year. So long as there was no speculative action on the Continental Bourses they could not expect any great increase of telegrams; but he was happy to say that the tide was turning, and they had never done a better business than during the last fortnight. (Hear, hear.) The expenses were a little higher than in the corresponding half of last year, but that was to be accounted for by the increased number of Hughes's instruments employed. There were now six of these working at Paris; and they used them whenever they had an opportunity, because, although they were more expensive than other instruments to purchase, and required an extra clerk to work them, the advantages in speed and accuracy fully compensated the company for the additional outlay. He was happy to say that the debenture debt of that company had been completely extinguished. (Hear, hear.) That company now stood in a position which was occupied by few companies connected with the City of London, that of having neither debenture debt nor preference stock, so that all the earnings went to the shareholders. (Hear, hear.) The cables were in excellent working order, and at that moment there was not a single sick cable. Of course that was in a great degree owing to the large sum which had been spent during the last year on renewals. That money had been well spent. Their steamer had been lying in the Granville Dock for the last eight weeks without going to sea, and the fact that when an accident occurred a few week ago the cable affected was repaired within two days, showed of what immense importance it was to have a steamer always ready for use. In conclusion, he congratulated the meeting on the condition and prospects of the company, which were never more sound and encouraging. (Cheers.) The motion was then agreed to, after which a dividend at the rate of 15½ per cent. per annum was declared. The retiring directors and auditors were then re-elected, and on the motion of Mr. Boys, a vote of thanks was given to the directors.

Prof. Palmieri has discovered a new instrument which he calls a "diagometer," and which is constructed for the rapid examination of oils and textures by means of electricity. What the apparatus will do, Prof. Palmieri details thus:—1. It will show the quality of olive oil. 2. It will distinguish olive oil from seed oil. 3. It will indicate whether olive oil, although of the best appearance, has been mixed with seed oil. 4. It will show the quality of seed oils. 5. Finally, it will indicate the presence of cotton in silken or woollen textures. The professor has been complimented for this invention by the Chamber of Arts and Commerce at Naples, who have published a full description of the apparatus, with instructions for use.—From *Nature*.

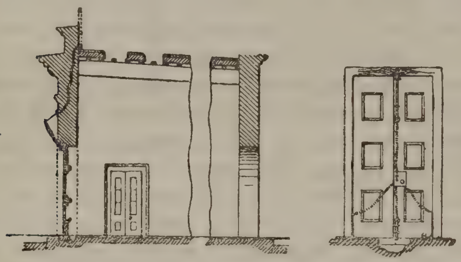
Correspondence.

To the Editor of the TELEGRAPHIC JOURNAL.

SIR,—On the night of May 31st, during a thunderstorm, the lightning struck the Brazilian Vice-Consul's house. The house, like most houses here, is nearly flat-roofed, with bricks laid on strong hard-wood battens and joists, and covered with flat, square tiles, laid in cement. On the roof over the door there was a flag-staff 18 feet long, and about 4 inches diameter at the lower end, and fastened to the parapet-wall of roof with iron staples. This was struck and shattered longitudinally into several

pieces, many of them not thicker than a lucifer match. One of the larger pieces, 10 feet long and 2 inches broad, was thrown on the roof of a house on the opposite side of the street, about 50 yards away. There were two holes made in the roof about 2 feet square—the first about a yard from the heel of the flag-staff, and the other 2½ yards from it, nearly in a straight line. The plaster on the front wall facing the street was cracked, and there was a small opening made diagonally from the staple that held the heel of the flag-staff through the wall down to an iron shield with coat of arms painted on it, that hung over the door; and where the lower part of this shield was fastened to the door-frame, the lightning seems to have passed through the frame, splitting and charring the wood, as if a red-hot iron had been passed through it, to a vertical iron bolt on the inside used for fastening the door. From the end of this bolt it ran along the wood-work, blackening it in its passage to the lock 3 feet from it. At the lock it divided itself into 3 parts—one running to a hinge on each side of the door, and from the hinges to the ground; the other part to a bolt at the foot of the door, and from thence to the earth, tearing up about 18 inches of the tiles on the floor.

A man and boy in the next room were thrown down.



The paint on the shield, bolts, hinges, and lock, were not in the least discoloured, but the lead-coloured paint on the door was blackened, showing where the lightning passed from one part of the iron to the other.

In the hole made in the roof the bricks and tiles were knocked away, but the wooden battens and joists remained intact. There were no pieces of metal in the roof, save the nails that fastened the battens to the joists.

It is easy enough to account for the pieces of the flag-staff being thrown to a distance, by the lightning decomposing the moisture in the pores of the wood, and the gas thus formed expanding, tearing, and scattering the fragments to a distance.

The holes in the roof might be accounted for in the same manner, by supposing that there were slight cracks in the tiles, and that these were filled with water, as it was raining at the time, and when the lightning ran along the wet roof it decomposed the water in these cracks, bursting holes in the roof and escaping over the wet surface of roof and wall in rear to earth. But I would like to know the opinion of some physicist on the subject, and if he can offer any other explanation. Perhaps you or some of your readers could oblige me. I enclose a sketch of the door, and a section of the roof and walls as they appeared the morning after the stroke.

I am, yours sincerely,
J. H. Bloomfield, F.A.R.

Concordia Republica Argentina.
4th July, 1875.

Notices of Books.

The Equatorial Needle, or a Compass which swings E. and W. &c. By W. A. Ross. London: E. & F. N. Spon.

The author informs us that these remarks were thrown hastily together, and are not to be considered as having been thoroughly digested. We quite agree with him. He has much to learn, especially of magnetism.

Explanation of the Double Balance Method of Duplex Telegraphy. By W. P. Johnston, Indian Government Telegraphs, Calcutta.

This is a pamphlet printed for private circulation, and is very ably put together. It describes the system of duplex telegraphy introduced into India by Mr. Schwendler, which is, in fact, Mr. Stearn's bridge method considerably overloaded with unnecessary resistances; so much so that "about four times the battery power employed for single working is required." It is said that the "*double balance*" has been adopted to avoid the objection that "in all the other known duplex methods, balancing the outgoing current at one station disturbs invariably the balance at the other station, and therefore if balance in any one station has once been disturbed, it can be regained only by successive adjustments in both stations." This is one of those among many objections which sanguine inventors, in describing their inventions, are so fond of indulging in, but we are surprised that such practical telegraphists as Messrs. Schwendler and Johnston should give currency to such a myth.

GATHERINGS FROM THE EDITOR'S NOTE BOOK.

When a cable is perfect, the tests of positive and negative currents are similar; when any flaw exists they vary.—(Thomson).

Christie invented Wheatstone's parallelogram in 1836, and it is described in the *Philosophical Transactions* for that year; and J. B. Cooke, proposed the shunt in 1847, which is also described in the *Philosophical Transactions* for that year.

The Messrs. Siemens first established the present careful system of testing cables upon the Malta and Alexandria cable in 1860, and were thus the means of introducing the Wheatstone bridge into general use.

Mr. C. F. Varley pointed out as early as 1856 that it was better to use zinc currents when testing a line for earth. The copper currents decomposed the water in the fault, and caused it apparently to disappear by coating the wire with oxide. The zinc current remedied this defect.

A contact between two wires, due to a bad earth at the terminal station, is easily determined by watching the direction of the currents. If the direction of the currents be the same at each station, it is bad earth; if different, it is on line.

One of the earliest and prettiest experiments, to show the repulsion due to similarly charged bodies, was devised and practised by Cavallo. He applied a feather to an electrified glass tube. The feather at first sticks to the glass; it becomes slowly charged, and then flies off. It is then easily maintained floating gracefully in the air, the same side being always presented to the tube. With an excited glass tube and an excited ebonite rod, the feather can be made to fly from one to the other like a shuttlecock. Faraday was very skilful in maintaining a gold leaf floating in the theatre of the Royal Institution, and Tyndall sometimes repeats the experiment.

THE TELEGRAPHIC JOURNAL.

Vol. III.—No. 64.

RAILWAY BLOCK SIGNALLING.

By W. LANGDON, M.S.T.E.

I.—Of the many important duties which electricity is called upon to perform, none are more so than that by which it is required to regulate railway traffic. For years the exigencies of railway service were such as to admit of the absence of such protection. With but few trains and stated crossing places, accidents were few and far between. The enormous and rapid growth of the several railway systems; the increased public demand for rapid and ready intercourse between all large centres of commerce; and the multiplicity of junctions has, however, reduced this system to one of both danger and difficulty. Day by day our railways are becoming more and more crowded, whilst the intermingling of heavy goods and mineral trains, with the rapid passenger and swift express, add to the difficulties which have to be encountered and overcome by the traffic manager.

Colonel Yolland has stated that "the danger of "running trains at intervals can only be obviated "by the block system of telegraph," and in one of his reports to the Board of Trade has confirmed this by the following decided expressions:—

"An interval of time, as a means of avoiding "collisions between trains, is, in my judgment, "worse than useless; it is deceptive and thoroughly "uncertain, as an interval of half an hour at one "station may have entirely disappeared before the "first train arrives at its next appointed stopping "place, whereas an interval of space, no matter "how short, between following trains, if preserved, "will always prevent a collision taking place.

"I am not arguing in favour of some imprac- "tical mode of working traffic, and laying myself "open to the remarks—that it is all very well in "theory, but will not answer in practice; but I "advocate, as the best means of preventing these "fearful collisions, the adoption of the electric "telegraph, and the working of the traffic on the "'block' system, of not allowing two following "trains to be between two adjacent stations at the "same time."

And Captain Tyler, in his report on an accident which occurred on the South Wales Section of the Great Western Railway on the 5th of November, 1868, says:—

"A mere interval of time, whether it be ten "minutes or twenty minutes, or any other given "quantity, affords no true margin of safety. "* * * * An interval of space is the only "true remedy for such a state of things, and it "matters not what the distance between the trains "may be, whether four miles or two miles, or half "a mile, so long as it is strictly preserved. "* * * * In this particular instance, an "interval of time of no less than twenty minutes "proved to be of no avail."

The Report of the Committee of the House of Lords on the Regulation of Railways Bill in 1872, gives the following as the result of their investigations.

"5. There is a general concurrence of opinion "among the witnesses in favour of the block "system on all important railways carrying "passengers.

"6. Experience has proved that this system is "compatible with the highest rates of speed.

"7. On some railways where the block system "exists on their entire lines, the speed is stated, "in the case of certain trains, to be between 50 "and 60 miles an hour.

"8. There are many single lines where the "block system has been found indispensable for "the safety of the traffic."

The power which electricity possesses, as an auxiliary, for facilitating and protecting the working of railway traffic is daily becoming more apparent to railway men. The numerous accidents which have occurred, and which could, and probably would, have been avoided had the block system been in operation; the constant recommendations, and of late the positive refusal of the Board of Trade to sanction the opening of lines without such protection; the general freedom from casualties on those lines on which it is worked out in its entirety; the frequency of accidents on those lines unprovided with it; and the wonderful assistance it affords in dense foggy weather and on crowded lines, are all reasons for its employment which none can ignore, and which must ultimately lead to its universal adoption.

Fig. 1.

For some time all railways were, and many still continue to be, worked upon what is known as the "*time*" system—that is, trains are not allowed to leave or pass certain points, or certain stations within a certain *interval of time.* Numerous and serious have been the accidents arising from this cause. A heavy goods or passenger train is started from a station, and an ample interval allowed before another train succeeds it. It may be this train is a fast or an ordinary train. If the former, so much the worse. The goods breaks down at a point, or is laboriously seeking its way up an incline hidden from the view of the coming train, which only becomes aware of its proximity too late to avoid a collision! Such has too frequently been the issue of a system which at its best can only insure the due observance of its principle at stations and junctions, in many cases few and far between, leaving miles of intervening line to chance and good fortune.

In the "block" system we have a method of regulating and protecting railway traffic, at once as simple and secure as is the "time" system complex and dangerous. A line worked upon this

principle is cut or divided into blocks or sections, the extent of each of which is regulated by the traffic to be worked over it. Where this is great, as is the case near the Metropolis and large towns, or busy junctions, the sections are shorter than where the traffic is less frequent. At all these points, signals for the guidance of the engine driver are erected. No two trains are allowed in any one of these sections, upon the same line of metals at the same time. Thus, let A B C D represent a portion of a line so arranged.

The train in the section A B must not enter the section B C until the train or engine in that section (B C) has passed out of it, and is clear of the signal C. By this means trains are kept apart by a given, certain, and invariable space; whilst by regulating these spaces or sections to the amount of traffic or number of trains required to pass over them, such traffic may be dealt with with perfect safety and confidence.

It has been stated that the lengths of the sections thus formed are regulated by the amount of the traffic to be dealt with. It will be evident that whereas these sections will, in some instances, extend to four or five miles in length, and sometimes even more, there will be occasions where their extent will be reduced even to half a mile. The outdoor signals erected at the point of division between the sections are the engine-driver's guide. Such signals may be worked mechanically a distance of a thousand yards, but under no circumstances can they be so worked a distance of four five or six miles. Here then electricity comes to our aid. By its means signals to indicate "Line clear," "Line blocked," or any other indication required, can be conveyed any distance in an inappreciable space of time. By such signals the signalman is guided in the working of his outdoor signals. A train enters section A B (Fig. 1) in the direction of B. Its departure from A is signalled to B, B records on the signal instrument at A, line blocked, and retains the signal in such position until the train arrives at, and is clear of B. On the departure of the train from A, A places his outdoor signals for trains proceeding in the direction of that just entered, the section A B, at danger, forbidding any other train whatever to follow, and he retains his signals in this position so long as B indicates to him by the signal instrument that the line is blocked. On the arrival of the train at, and its departure from B, B removes the block signal, replacing it by an all clear signal, and the signalman at A then replaces his outdoor *danger* signal by an *all clear* or *caution* signal, according how the line or station is worked. It will thus be seen that with such a power at our command, it only remains to apply it in its simplest and safest form, and to reduce its application to a system such as shall meet the exigencies of the traffic, whilst securing the maximum of safety.

(To be continued.)

ON THE TELEGRAPHIC PROBLEMS OF DOUBLE SENDING AND QUADRUPLEX TELEGRAPHY.

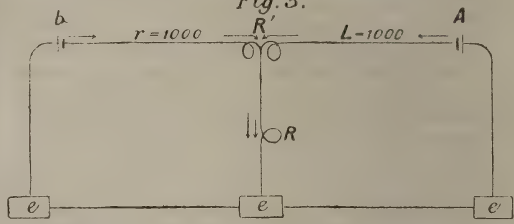
By G. K. WINTER,
Telegraph Engineer to the Madras Railway.

(Continued from page 208.)

To begin with, then, I attacked the problem by the second method, that is to say, I said, let there be four variations of current; how can I cause these four variations to produce, on two Morse instruments, the four necessary combinations? The apparatus to be so arranged that no kick shall be produced on either of the Morses, at any of the moments of change from one variation to another; and also that the adjustment of the arrangement shall not depend in any way on differences in the sensitiveness of relays.

This is the problem I set myself, for I took it for granted that when once this had been solved the arrangement of the keys to produce the required variations would be easily accomplished.

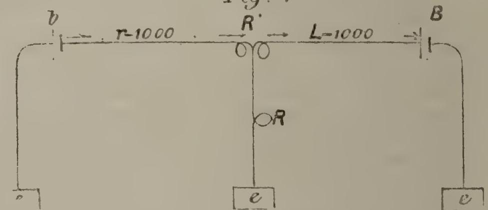
Fig. 3.



In Fig. 3 let L be the line, with a resistance, say of 1,000 units, and let r be an artificial resistance. Let b be a local battery, and A a battery at the distant station, of equal strengths, and sending their currents in the direction indicated by the arrows, e e e are earth plates. R^1 is a relay wound differentially, and R is another relay, not wound differentially, but connected between the middle point of R^1 and earth, as shown in the figure.

It is evident that the two currents will neutralize each other's effect on the relay R^1, but that they will both flow through R in the same direction. R^1 will evidently not work, but R will.

Fig. 4



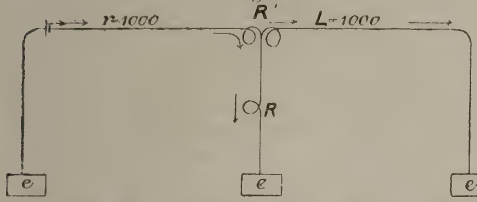
Again, let Fig. 4 represent the same arrangement, except that the direction of the battery B is reversed, as shown by the arrows. Then the currents will flow in the same direction through the two coils of the differential relay R^1, which will consequently work, whereas no current will flow through R, as the potential of the circuit at the centre of the differential relay will be zero, the batteries being equal in power and the resistance equal on each side of this point. Thus in this case the relay R^1 will work, but not the relay R.

Next, let us have no battery applied at the sending station, but the line joined to earth as shown in Fig. 5.

It is now evident that both relays will work, for a large portion of the current from b will flow through R to earth. Thus, with three variations of current coming from the sending station, we can produce three of our four combinations. It remains to be seen how we can produce the fourth.

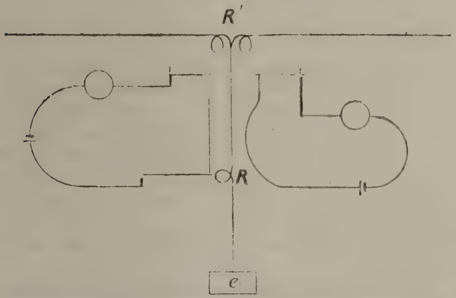
Let us suppose the differential relay R^1 to have two tongues, and let the connections be made as shown in Fig. 6. Further, let this relay be polarised, and let both its tongues be worked by a current in the direction shown by the arrows in Fig. 5.

Fig. 5.



We must also suppose that when in a state of rest, that is, when no current is passing through the relays, the tongues will be in the positions shown in Fig. 6.

Fig. 6.



Things being thus arranged, let a current from S be sent, as shown in Fig 7.

1st. If we have two units of copper current from S, the sending station, that is in the direction shown by the double arrow in Fig. 7, both tongues of the relay R^1 will be open, so that, notwithstanding that the tongue of relay R is closed, the circuits of both morses will be broken, and those instruments consequently at rest.

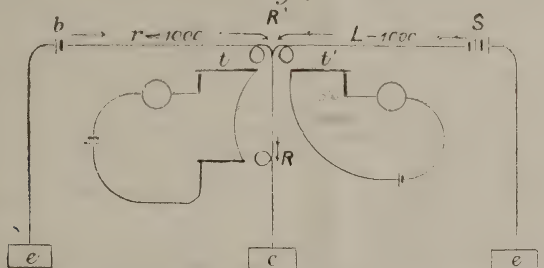
2nd. If we have only one unit of current flowing in this direction from the sending station, the currents flowing through R^1 will balance each other, and consequently the tongue t will go to its position of rest, that is to say against its contact stud, and as the currents flowing through R still cause its tongue to remain against its contact stud, we shall have the local circuit of morse A completed, and therefore that instrument will work. The tongue t^1 of relay R^1 will on the contrary remain in its position of rest, that is, against its insulated point, and consequently the circuit of morse B will be opened, and therefore that instrument will be at rest.

3rd. If we have one unit of zinc current, that is, as shown in Fig. 4, we shall have both tongues of relay R^1 closed, but the tongue of relay R will be opened, as that relay will have no current passing through it, and its tongue will therefore go to its position of rest against its insulated point. We shall therefore have the circuit of morse B closed, but that of morse A open.

4th. If no current arrives from S, all the tongues will be closed by the action of the current in the local circuit, and consequently both morses will work.

At the sending station, then, we want such an arrangement of two keys as shall produce the following variations of currents, by their four combinations.

Fig. 7.



We shall then have a current running through one coil of R^1, not only in a direction opposed to that from b, but also of double the strength, and consequently, the resultant magnetic effect of the currents on this relay will be to give it a polarity which will be opposed to its working; thus, not only is the tongue t^1 allowed to fall away from its contact, but is held in that position while the tongue t is also forced away from its central point against which it leans during all the other variations of the currents received from S.

Hitherto we have supposed the resistances on each side of the differential relay to be equal, but it will be seen at once that we may reduce the resistance r, if we reduce the number of cells in the battery b in the same proportion; we may thus easily reduce this battery to one cell.

To recapitulate then, we find that—

1st. A copper current of two units when both keys are at rest.
2nd. A copper current of one unit when key A is depressed.
3rd. A zinc current of one unit when key B is depressed.
4th. No current when both keys are depressed.

(To be continued.)

ON TELEGRAPH CONSTRUCTION.

By JOHN GAVEY, Assoc. Soc. T. E.

IRON.

A very brief glance at the methods of manufacturing this metal is perhaps advisable. Very little native iron is found on the earth's surface, but in com-

bination with various substances, and known under the general name of iron ores, it is widely distributed. The ordinary method of obtaining the metal from these ores, consists in exposing the latter to a very high temperature, in contact with compounds calculated to enter into chemical combination with the earthy or gaseous substances united with the iron. Sometimes the ore is first calcined, or roasted in great heaps, to expel the more volatile compounds; sometimes it is filled direct into the furnace, which is a huge structure, varying from fifty to sixty feet in height, and of a corresponding width. This furnace, when once started, is kept in uninterrupted action until the necessity for repairs, or the reduction for the demand for iron renders it necessary to blow it out. The charges of material, consisting of fuel, ore, limestone, &c., are fed in regularly at the top, the liquid iron and other compounds being withdrawn from convenient openings near the base. The necessary draught is obtained by powerful blowing engines, which force strong currents of air, generally heated to a temperature of about 600 degrees, into the furnace. A very high temperature is attained within the furnace; the metallic iron melts and drops on the hearth, whence it is periodically drawn off and run into moulds, whilst the slag, resulting from the combination of the earthy portions of the iron ore with the fluxing material which has been added, floats on the surface of the iron, and is drawn off through a convenient opening, and carted away to the "waste tip."

The pig or cast iron thus obtained, is an indefinite compound of iron, with quantities of carbon, varying from two to five per cent. The properties of cast iron are well known. It has a brittle crystalline structure, possessing great hardness, and offering considerable resistance to a crushing force, but with a comparatively small tensile strength, or power of resisting torsional or tranverse strains.

Iron deprived of its carbon and some other impurities, is known as malleable or wrought iron, and the operation by which this change is produced is that of puddling. The cast iron is placed in a reverberatory furnace, which is so arranged as to cause the heat and flame from the combustion of the fuel to impinge on the surface of the metal. The latter speedily melts, and when in this state it is kept stirred, so as to bring fresh surfaces of iron constantly under the influence of the flame and hot gases. The effect of this is to consume the carbon in the iron, which latter gradually loses its fluidity, and becomes viscous and pasty. In this state portions of the iron are worked up into rough spongy balls, and placed under powerful hammers, where they are wrought into rough plates. These plates are cut into smaller pieces, which being tied together, are again heated, and either rolled or hammered, the operation being repeated in some cases several times. The quality of the iron is much improved by this, and it thereby acquires that fibrous appearance, which is a characteristic of good wrought iron.

Wrought iron has very different qualities to cast iron. Its power of resisting crushing strains is diminished, but its tensile strength is enormously increased; it has, when of good quality, none of the brittleness of cast iron, it is easily bent, it becomes malleable, is readily rolled into sheets or bars, is susceptible of being drawn into wire, and possesses the quality of welding at a white heat, although it has lost that of fusing or melting at the comparatively low temperature which the combination with carbon gave to it.

Steel is a certain definite mixture of pure iron and carbon, the proportion of the latter being much less than in cast iron, but varying very considerably according to the purposes to which the finished metal has to be applied. The higher class of steel is made from the best malleable iron, by exposing the latter to heat in contact with carbon, the process being known under the name of cementation; but within the last few years, systems of manufacturing steel direct from cast iron have been largely introduced. One process, due to Mr. Bessemer, consists in consuming the carbon, by forcing a quantity of atmospheric air through the melted metal, then by the addition of a definite proportion of highly carburetted iron, the exact quantity of carbon needed for the formation of steel is restored to the liquid mass.

Steel possesses many and various qualities, dependent to a great extent on the purposes for which it is manufactured. Its tensile strength and resistance to crushing forces are much greater than wrought or cast iron. It also is susceptible of receiving any given degree of hardness, by the process known as tempering, from that which is sufficient to scratch glass to very little above soft iron.

The strength of iron, whether cast or wrought, and of steel, varies between very wide limits, according to the purity of the metal, the method of manufacture, &c.

Cast iron has been produced with an ultimate tensile strength of 14 to 15 tons to the square inch, but this is rare. The average may be taken at seven tons, though it is occasionally as low as four to five tons. The force necessary to crush short cylinders, varies from 35 to 59 tons per square inch, and the average may be taken at 45 tons.

Wrought iron may be said to have, in extreme cases, a maximum tensile strength of 30 tons, and an ordinary or average strength of 23 tons to the square inch, although this sometimes falls as low as 19 tons. These figures do not apply to the strength of wire which, within certain limits, is greater in proportion as the sectional area is less.

Steel may be said to have a tensile strength varying from 33 to 53 tons per square inch of section.

A form of cast iron, known by the name of malleable cast iron, is frequently used in minor fittings for telegraph work. It is prepared by exposing castings, immersed in oxide of iron, or other substances rich in oxygen, to a high temperature, and allowing them to cool gradually. The oxygen combines with a portion of the carbon, and the withdrawal of the latter imparts a remarkable degree of toughness to the material so treated.

Iron poles. These have not to any great extent been used in England. The principal objection to their extended introduction, is the heavy cost of that material as compared with wood. At first sight it might appear that their increased durability would counterbalance this, but except in localities where ornament is an object, it is not so, Creosoted timber is so durable, that it is quite possible that it may equal the duration of wrought iron, and even though it do not, the difference in cost is so striking, that the balance of advantages remains in

favour of the former for use in this country. Abroad, and especially in tropical countries, iron poles are very extensively used, as they present many advantages over timber. The use of iron admits of the material being so disposed, as to obtain the maximum strength, with the minimum material; the poles are likewise generally constructed in sections, so that by these means great facility of transport is attainable, a point of much consideration in countries which have not well developed systems of roads, and means of transport. Moreover, iron is of course proof against that great enemy of timber, the white ant, which is so common within the tropics.

In the application of iron to Telegraph poles, the main objects to be kept in view should be, the obviating of the destructive effects of oxidation, and the distribution of the materials in such a form as will combine strength, lightness, and elasticity.

These two objects are generally attained by constructing poles of a combination of wrought and cast iron, the latter being used for that portion which is fixed in the ground, and which rises some height above it, and the former being employed for the upper portion of the pole. The advantage of cast iron for the base piece, consists in its durability, it not being subject to oxidation under the influences which generally affect Telegraph poles, and also, because an ornamental character is, where necessary, readily and cheaply imparted to it. Wrought iron is used for the upper portions on account of its greater strength, and its superior elasticity, whereby it is better able to resist the sudden strains and jerks to which it is subjected during rough gales. The various sections of which an iron pole is constructed, may either be held together by friction, tapered joints being provided, or they may be fitted with sockets and secured by lead or other suitable cement.

Iron has, however, been applied in many ways to the construction of telegraph poles; sheet iron wrought into various forms, rolled tapered tubes, bars, ribbons, angle iron, and cast iron cylinders, being variously combined. As an example of each class, we will describe briefly a few of the best known.

Hamilton Standards are examples of poles constructed principally of sheet iron. They are formed of plates varying from a $\frac{1}{4}$ to $\frac{3}{8}$ of an inch in thickness, bent into a circular form and rivetted, so as to furnish tapered cylinders about eight feet long. The sections for each post vary slightly in mean diameter, so that when fitted one over the other, poles of a uniform taper, varying from 16 to 40 feet long may be constructed.

The base consists of a cast iron taper cylinder, over which the lower section fits, and it is provided at the bottom, either with two cross pieces of angle iron, or with a base plate, which adds to the groundhold of the pole. The poles are, for convenience of handling and transport, shipped in sections, and fitted together *in situ*.

These poles are now generally galvanized, as if this be not done it is found that they oxidise very rapidly. It is stated that in some cases, when exposed to the action of salt water and not galvanised, poles of a similar character have been destroyed in four years.

Siemen's Iron Poles, which have been very extensively used, consist of a wrought iron cylindrical base piece, at the bottom of which is bolted one of Mallett's buckled plates. These plates consist of sheets of rolled iron, about three feet in diameter, to which great stiffness is imparted by their being dished, or bent into a dish-like curve. The upper portion of the pole consists of a continuous rolled taper tube, which fits into a socket in the upper portion of the cast iron base piece, into which it is cemented by means of a mixture of sulphur and oxide of iron.

Cast iron cylindrical tubes, strengthened by collars or bands of wrought iron, and fitting telescopically, have been employed as well as wrought iron, either in a taper form or varying by gradations, and attached to a cast iron cylinder fitted into the ground.

Some poles have been constructed of a species of lattice work, somewhat similar to those frequently used for signalling purposes on railways. These, however, are too costly for general use. A modification of this, termed a riband pole, has been manufactured. It is of cylindrical form, constructed with thin bars or ribands of iron, crossing one another at regular angles, rivetted together, and strengthened with angle irons. The facility with which these poles could be climbed would perhaps be found objectionable on high roads, even though the advantages they might possess rendered their use advisable. Little or no practical experience has been obtained of their value.

For light work, we have extemporised iron poles from a few lengths of different size cast and wrought iron gas pipes, fitted telescopically. These, with the aid of ornamental cast collars, have occasionally served the required purposes in emergencies.

Iron is largely used for overhouse work, and with advantage. For this purpose, rolled taper tubes, either whole or fitting telescopically, are the most advantageous. They fit at the base into a semicylindrical iron casting, which can be adapted, either for use in a roof gutter, or fixed on a ridge. The work looks light, is durable, and requires less attention than wooden supports.

The proportions which should be given to iron poles, either of cast or wrought iron, will be considered when we deal with the pole as part of a complete structure.

As has been previously remarked, iron poles in this country are used primarily in localities where the ordinary wooden structure being objected to, something of an ornamental character is needed. This involves certain difficulties, for in traversing a town the ordinary facilities for staying do not generally exist, and if an iron pole be made sufficiently large and strong, to withstand of itself the strain of the wires it will have to carry on curves and at angles, it becomes as unsightly as a wooden one. This difficulty is met by reducing the size and consequent strain of the wires, and then by using two or more sizes of poles, one, as light and airy a structure as is suitable for straight lengths, the other heavier, for curves and angles. As a rule, two dimensions of poles should serve for any given work, and uniformity of design, should for each work be preserved, the strength only being varied. The stiffness of light poles may be increased by trussing.

Iron Sockets to screw into the ground, and adapted for holding wooden poles, have been ex-

perimentally tried, with results, so far as the additional durability imparted to the timber is concerned, of a somewhat varying and disputed nature. Taking into account the cost of the sockets, and the additional labour in fitting the joints, it appears that their extended use cannot be considered economical in this country. They were likewise tried in India some years ago, but the iron socket was gradually lengthened and the timber pole shortened, until the latter was wholly abandoned and the socket grew into a complete iron post.

RESISTANCES AND THEIR MEASUREMENT.

By H. R. KEMPE.

(Continued from page 158.)

XIX.—*Joint Testing.*

JOINTS are the weak points in a cable, and it is therefore essential that they should be not only carefully made but carefully tested.

A joint being a very short length of the core offers, or should offer, a very high resistance, it would therefore be impossible to test it by a direct deflection method, that is, a method similar to that by which the insulation resistance of a cable is taken. Even with a very powerful battery the galvanometer deflection, provided the joint be good, would be almost inappreciable, consequently another plan must be adopted. The one most generally employed is that known as Clark's accumulation method.

A gutta-percha or ebonite trough is provided, which is suspended by long rods of gutta-percha or ebonite from any convenient hook.

The good insulation of the trough is of great importance, and consequently the suspending rods should be as dry and clean as possible. It is usual to give them a rub with a piece of parraffined rag, which prevents the formation of a conducting film of moisture on their surfaces. We may here remark that *surface* leakage is almost the only thing to be feared in electrical apparatus, and this should always be seen to by keeping all surfaces, over which leakage is likely to occur, clean and bright. The peculiar formation of ebonite causes minute quantities of sulphuric acid to form on its surface, which, however, may be removed by washing with clean water. It is as well to do this before rubbing with the parraffined cloth.

The trough is filled with water in which the joint to be tested is immersed, and held down by two hooks placed at the bottom.

The portion of the core on either side of the joint should be carefully dried, for the same reason that the suspending rods were so treated.

A metal plate is placed in the water in the trough, and connected to the front terminal of the discharge key. A battery of about 200 cells has the zinc pole connected to one end of the conductor of the core, the other end of which is insulated.

The other pole of the battery is connected to one terminal of a condenser, the other connections being the same as those for taking the measurement of a condenser discharge.

The whole arrangement is, in fact, the same as this latter, with the exception that the pole of the battery which would be directly attached to the front stop of the discharge key is in this test connected to it through the medium of the joint.

In order to ascertain whether the insulation of the arrangement is good, before commencing to test, place the battery wire which would be connected to the core, in the trough. Charge and discharge the condenser and note the deflection obtained. Again, charge the condenser and before discharging it remove the battery wire from the trough, and then after one minute take the discharge; this should be the same, or very nearly the same, as that obtained at first. If not, the insulation is defective.

The insulation being obtained satisfactory, place the joint on the trough and connect the battery wire to it.

The discharge key being pressed down, the battery charges the condenser through the joint.

After a certain time, usually one minute, the discharge deflection is noted.

A similar measurement is also made, using about 6 feet of perfect core, in the place of the joint.

If the discharge deflection after the same interval of time, in this case, is not less than that obtained from the joint, the joint is considered defective and is re-made.

A thoroughly perfect joint it is evident should test at least as well as an equal length of perfect core, and the fact that so long a length as six feet of core is taken as a comparison, shows that the present system of jointing is far from perfect.

When only one observation each is taken with the joint and the core the results obtained are only roughly comparative ones, and do not represent accurately the comparative resistances of the two, for if both discharge deflections were taken after larger equal intervals of time, it would be found that the ratio of the two results obtained at first would not agree with the ratio obtained when the results were taken after longer or shorter equal intervals of time. By taking, however, a second reading with each after longer or shorter intervals true comparative results may be obtained.

Thus the resistances of the two can be worked out from the formula—

$$R = \frac{T}{C \log._e \frac{V}{v}}$$

which formula we must point out, is as true for the case in which a condenser is charged through a resistance as for the case in which it discharges itself through a resistance, the T in the former case being the difference between the times after which the observations are taken. Thus, if the first observation were made after 20 secs., and the second after 30 secs., T would be 30 — 20=10 secs.

If we simply require the comparative resistances, then we have

$$R_1 = \frac{T}{C \log._e \frac{V_1}{v_1}} \qquad R_2 = \frac{T}{C \log._e \frac{V_2}{v_2}}$$

therefore

$$R_1 : R_2 :: \log._e \frac{V_2}{v_2} : \log._e \frac{V_1}{v_1}$$

V_1 and v_1 being the potentials observed at the beginning and end of the difference of time T, with say the joints, and V_2 and v_2 the potentials observed also at the beginning and end of the difference of time T with the length of core.

The system of charging the condenser through the joint cannot of course be made unless one end of the core is at hand to which to attach one pole of the battery.

When a joint is made in a cable core at sea neither end can be got at. The resistance, however, could be measured by arranging with the shore, before the joint is made, that at a certain time the end of the cable shall be put to earth. The rate at which the charged condenser would discharge itself through the joint could then be observed, and the resistance calculated from the regular formula.

To enable the tests for fall of charge to be made readily when the condenser and resistance are not in one, as in a cable, the connections may be made as shown by fig. 29.

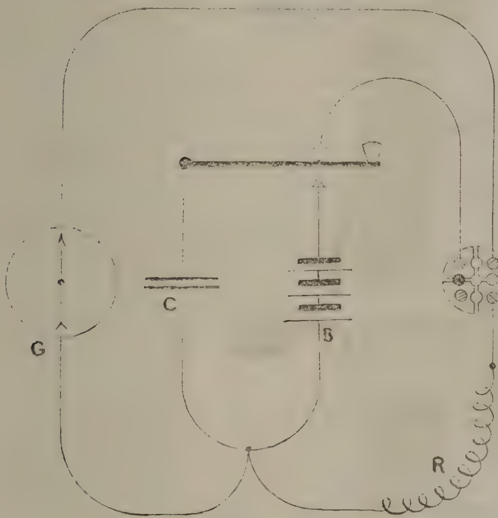


Fig. 29.

The plug switch S has one of its plugs placed in the left hand hole permanently. Another plug is placed in the bottom hole, and the key being pressed down so as to charge the condenser, the "discharge" trigger is pressed, and the condenser commences to discharge itself through the resistance R. After a noted time the key is again pressed, but only far enough to hitch it on to the "insulate" trigger.

The plug is then removed from the bottom to the top hole in the switch, and the "discharge" trigger being pressed the discharge deflection (v) is obtained on the galvanometer.

When testing a joint on board ship the terminal of the switch, which is joined to one end of the resistance in the Fig., would be attached to the metal plate in the testing trough, and the wire attached to the other end of the resistance would be put to earth.

GRAMME'S MAGNETO-ELECTRIC MACHINES.

By ALFRED NIAUDET-BREGUET.

(Concluded from page 200.)

Lighting Machines.

The first machine of this description weighed 1,000 kilogrammes, and gave a light equal to 900 burners. It had 3 rings and 6 electro-magnets. One of the rings excited the electro-magnet, whilst the other two supplied the lighting current. The copper twined round the electro-magnets weighed 250 kilogrammes; that round the 3 rings 75 kilogrammes. Its measurement was 80 centimetres in width; 1·25 metre high. This apparatus, for a long time used in experiments on Westminster Tower, grew warm when in action, and remitted sparks between the metallic brushes and the bundle of conductors upon which the current accumulates. However, for two years, it gave rise to no serious inconvenience.

Monsr. Gramme endeavoured to eliminate the sparks and the heating of the machine; and, as the intensity of the light demanded by various governments did not exceed 250 burners, he was impressed to reduce the dimensions of his first machine, as shown by Figure 6. The instrument still had 6 electro-magnets, but, instead of being grouped in straight lines, they form triangles: the total current from both rings may be sent into the magnets, or one only, or lastly, the whole of it may be made to produce two separate lights. Its statistics are:—

Weight	700 kilogrammes.
Height	90 centimetres.
Width	65 ,,
Copper on electro-magnets..	180 kilogrammes.
,, two rings	40 ,,
Normal light	500 burners
Light from great speed	1000 ,,
Sparks and heating..	nil.

The latest type is shown by Figure 8, and embodies vast improvements on all previous machines of this class.

Its form is of the same character as that of the electroplating apparatus: its weight is 183 kilogrammes; requires but 47 kilogrammes of copper for the ring, and the same quantity for the electro-magnets. Length, 55 centimetres; width, 55 centimetres, and height 60 centimetres. Normal power about 200 burners, but it will reach much higher.

The following are the mean results of six series of experiments:—

Number of Turns.	Number of Burners.	Remarks.
650	77	No heat nor sparks.
850	125	,, ,,
800	150	,, ,,
900	200	,, ,,
935	250	Slight heat, no sparks.
1025	200	Heat and sparks.

Among the improvements introduced into this machine may be mentioned the construction of the central ring, according to the "double" principle already referred to; an arrangement whereby the sparks disappear. By suitable means it can be joined up for "intensity" or "quantity," or it may be used to produce two distinct lights instead of one only. This capacity for one machine to produce two lights is of practical benefit for the reason

that, when one light only is used, its enormous dazzling power casts many objects into deep shadows. By dividing the position of say two separate lights this objection disappears. M. Gramme constructed machines of from 50 to 100 burners—so arranged that clusters of burners may be variously placed. For some time his own study has been lit up by a single lamp, placed sufficiently high to prevent the eyes catching sight of it, excepting designedly. The light is located in a diffusing globe in such a manner that it is not a shining point, but a large white brilliant globe—hence the strength of the shadows are much lessened.

We will say very little regarding the electric light for light-houses. Eleven years experience in the Hève lighthouse without one night's interruption scarcely admits of a doubt, but that the large lighthouses will, before long, be all provided with Gramme's machines. The capability of producing two lights mey be of service even in lighthouses by placing one above the other—a very striking and distinctive sign. In addition, we merely hint that the uses to which Gramme's machines might be put to as signal lights on board ships, are very easily suggested to the thinking reader.

Various Industrial Uses.

Small machines have already found their way into several industries, such as electroplating. In numerous factories, likewise, where Bunsen's, Grove's, or bichromate of potash batteries are used, it would be advantageous to employ Gramme's machines. Some instances in which they might be specially used as exciters of magnetism are:—1. Electro-sorters, or apparatus for the separation of iron or the oxides of magnetic iron from certain mixtures. 2. For miners' lamps which are (in some places in France) unable to be opened except by a very powerful electro-magnet. These lamps are very simply constructed. They are closed with a bolt, which can only be withdrawn by a special electro-magnet in charge of the lamp-keeper: no

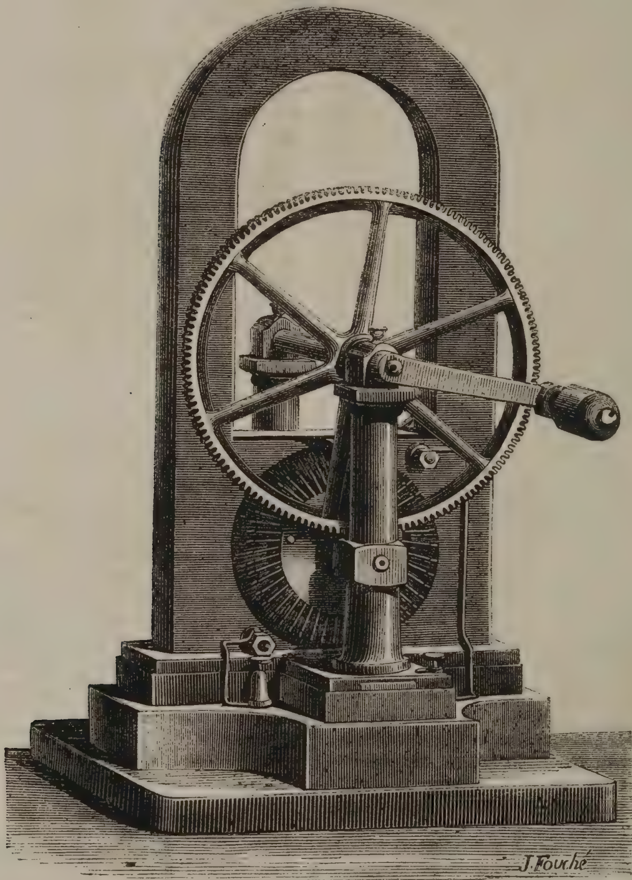


Fig. 7.

knife, nor other power on the miner's part, can withdraw it. Formerly these lamps were closed or opened by an electro-magnet excited by means of a bichromate of potash battery; but so much trouble was experienced from it, that Gramme's machine has been substituted for it. The machine being worked by a treadle, leaves the operator's hand free to handle the lamps. 3. In combination with a Planté secondary pile, whenever an intermittent current is wanted at regular or irregular intervals. For example, on board of a ship, or on the top of a lighthouse, brilliant lights at periods of five seconds in every minute may be required. These may be obtained from a battery of 20

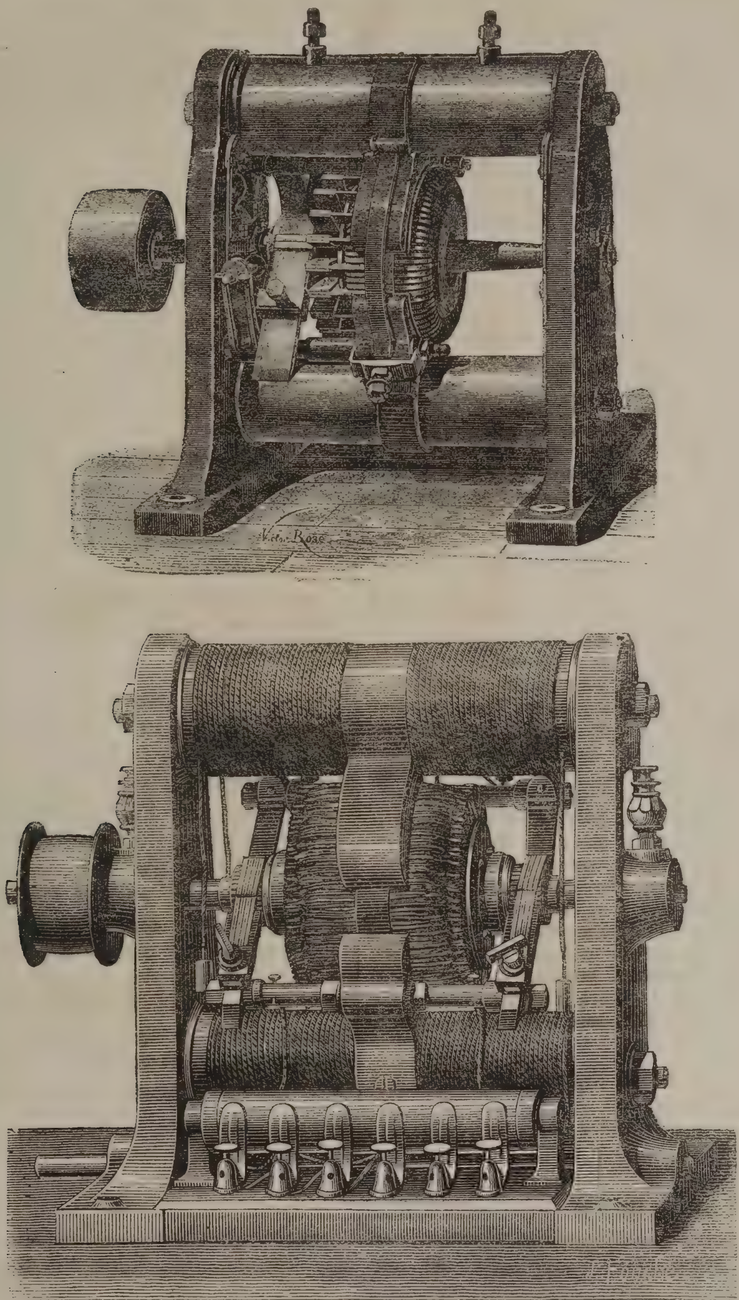


FIG. 5 and FIG. 8.

secondary couples to be recharged during the complementary 55 seconds. A brilliant light of 5 seconds duration per minute may be produced equal in intensity to the constant light obtained from a machine twelve times larger. 4. Amongst its advantageous uses in medicine may be cited, the cauterising, by means of a red hot platinum wire; and the chemical decomposition of tissues in the case of certain tumours. M. Moret, of Paris, has declared, after trial of a small Gramme, that it unites in itself all the conditions desired in therapeutics; and he has expressed his belief that it is the universal electrical medical machine of the future. Figures 4 and 8 are engravings of two such instruments suited to medical requirements.

Transmission of Force to a Distance.

Since the current produced from one instrument will perform work in another, it is evident that the transport of mechanical force to a distance may be accomplished; for whatever action one machine assumes, the other, no matter the distance (provided the current is of sufficient strength), is similarly controlled. This idea might be of great utility to engineers, who could make use of the motive power of waterfalls so abundant among mountains, and other natural forces, to work the current-producing machine.

The Seine, in point of illustration, is canalized throughout its whole course; a series of weirs putting it absolutely in the hands of engineers, who regulate it at pleasure. At each of these weirs a difference of level more or less great exists, and consequently we have the possibility of establishing regular falls and turbines to utilise them. Now, to remove manufacture around these various weirs is not possible; but it is easy to transport their forces, by means of magneto-electric apparatus, into the neighbouring towns. Some of these weirs possess great power which is entirely lost; thus at Port-à-l'Anglais the force daily lost is 3,000 horse-power. It is close to the town, and could be easily saved to the community.

At the risk of being considered chimerical and dreamers, we maintain that, although unforseen difficulties may present themselves, this new mechanical combination will probably introduce an industrial and economical revolution throughout commerce, in places where natural forces are available at moderate distances from centres where power is required.

Notes.

The following method is used in Germany for the preservation of wood:—Mix forty parts chalk, fifty resin, four linseed oil, melting them together in an iron pot; then add one part of sulphuric acid, and apply with a brush. This varnish, when dry, is as hard as stone.

The Isle of Man cable was successfully laid on the 19th instant between the old landing place at St. Bees, near Whitehaven, and near Ramsay in the Isle of Man. Communication was re-established on the 20th inst., after many months' interruption,

Notice has been received by the Indiarubber, Gutta Percha, and Telegraph Works Company that the section of cable between Iquique and Caldera has been successfully completed. This brings Peru and Chili into telegraphic communication with Europe. The sections laid are from Callao to Arica, Arica to Iquique, and now Iquique to Caldera, thus completing the Peru-Chili connection.

The manufacture of the New Zealand Cable is steadily progressing, and arrangements are being made for its shipment: the "*Hibernia*" and "*Edinburgh*" will be employed on this work. The first vessel will be despatched early in the present month, whilst the second will follow early in November. The total length of cable being manufactured is 1,370 knots. The core consists of 107 lbs. copper, and 140 lbs. gutta-percha of Willoughby Smith's improved manufacture. There are four types of cable—10 miles of shore-end, 59 miles of intermediate, 300 miles of deep sea of the Mediterranean type—a solid covering of No. 13 galvanized homogeneous iron wire, protected with yarn and compound—and 1,000 miles of special deep sea cable; this type consisting of 9 strands of hemp, alternating with 9 No. 13 galvanized homogeneous iron wires, the whole being well protected with compound.

Immediately after the announcement of the Direct United States Cable Company, the Anglo-American Company announced a reduction of rates from 2s. per word to 1s., from the 15th September, allowing, as initiated by the Direct Company, the name of office of origin to go "free." The Direct immediately followed suit, and reduced their tariff to 1s. per word, and at the present time this arrangement is in force; shares, however, went up on the report that the Directors were endeavouring to arrive at mutually satisfactory working terms. The receipts of the Direct have not yet been published, but the Anglo-American have announced the following:—Sept. 15 .. £1,020

(This would include some at 2s. rate)

,,	16 ..	890
,,	17 ..	790
,,	18 ..	780
,,	20 ..	690

This is sufficient to show at once that the reduced rate has more than doubled their traffic.

At a meeting of the Board of the Anglo-American Telegraph Company, held lately, it was resolved to pay an interim dividend of £1 per cent., free of income tax, for the quarter ending the 30th of September, payable on 1st of November, leaving an estimated cash balance of £18,000, in addition to £25,000 placed to reserve. The register of

transfers of the company will be closed from the 27th September to the 2nd October, both inclusive.

The West India and Panama Telegraph Company (Limited) give notice of the interruption of the Santiago de Cuba—Jamaica and Punta Rassa—Key West Cables, thus cutting off direct telegraphic communication with the West Indies viâ North America. By the recent opening of the Para - Demerara Cable, however, direct communication by wire is established viâ Lisbon and Pernambuco with Para, Cayenne, Demerara, the Isthmus of Panama, and all the West India Islands except Cuba. The tariff by the new route may be obtained at 74, Old Broad Street, and at all postal telegraph stations.

The Indo - European Telegraph Company (Limited) notify that the Singapore-Batavia Cable is restored, and that messages for Java and Australia are accepted as usual viâ Teheran.

The Eastern Telegraph Company (Limited) also announce that the communication being now restored, messages can be sent as usual if directed "viâ Suez."

Referring to the notice of interruption of telegraphic communication with the West Indies, the Cuba Submarine Telegraph Company (Limited) announce that messages for Cuba continue to be forwarded for their destination viâ United States. In consequence of the interruption of the Punta Rassa—Key West Cable of the International Ocean Telegraph Company—these messages will, however, be subject to a short delay.

The report of the Direct Spanish Telegraph Company (Limited) states as follows: — "The balance at the credit of profit and loss is sufficient to pay, after providing for the 10 per cent. preference dividend, a dividend at the rate of 5 per cent. per annum on the ordinary shares, leaving a balance of £429; but inasmuch as the half-year ending 30th June was commenced with a reserve fund of £704 (since absorbed in the repairs of the Santander Cable), the directors deem it prudent to recommend a dividend of 4 per cent. per annum on the ordinary shares, and to replace this sum of £704, together with a further sum of £307 to the credit of the reserve fund, so as to begin the current half-year with a total of £1,011.

The delay which has recently taken place in telegraph messages from Australia and Java is owing to the Eastern Extension Company's cable between Singapore and Batavia having been under repair. The communication which was interrupted is now restored, and messages can be sent as usual if directed *via* Suez.

PNEUMATIC TELEGRAPHS FOR LONG DISTANCES.

Paper read at the meeting of the Society of Civil Engineers of Paris, on the 4th June, 1875.

By M. A. CRESPIN.

(Concluded from page 204.)

I now proceed to the consideration of the speed with which the boxes will travel in a pneumatic line of unlimited length, in which, by the methods described above, the vacuum will be kept at 0·5 metres of mercury, and the pressure, admitted by the relays at intervals of 1,000 metres, equal to 0·76 metres of mercury; the tube to be one-tenth of a metre in diameter.

My point of comparison will be the speed in the tubes of the Paris system, where a pressure of 0·4 metres of mercury gives a speed of 20 metres per second, in a line 1,000 metres long, and 0·066 metres in diameter.

The increase of diameter will increase the speed in the proportion

$$\sqrt{\frac{100}{65}} \text{ or } \frac{10}{8}$$

say 25 metres per second.

The fact that the line if kept exhausted of air will reduce the friction in each length of 1,000 metres to an average equal to that of 600 metres at most, for at the beginning of each section, that is to say, at the moment when the train passes the pressure relay, there is no column of air travelling with it; at the termination of the section only, will the column of air which drives the train have a length of 1,000 metres. If the vacuum were perfect, the average friction length of the column of air would be but 500 metres. The diminution in the frictional length of the column of air gives an increase of speed in the proportion

$$\sqrt{\frac{1000}{600}} = \frac{33}{24}$$

The speed, raised to 25 by the increase of diameter, now becomes

$$25 \times \frac{33}{24} = 36 \text{ metres.}$$

We have then the increase of the difference of pressures, which is also in the ratio of the roots

$$\sqrt{\frac{26 + 50}{40}} = \frac{115}{65}$$

The application of this last ratio indicates a speed of nearly 70 metres per second.

This is an enormous speed, and would in all probability be attended with some inconveniences, but it is evident that we should work with the highest speed possible.

Now, observations made with trains running under similar circumstances at speeds of 40 to 50 metres, have shown that these practical speeds are quite admissible in regular working. It is only necessary to employ a very strong material, arranged in such a way that it alone shall wear without wearing the line; this end is attained by fitting the rubbing parts of the boxes with a softer metal than that composing the line.

The two ends of the line are provided with apparatus suitable for sending and receiving, in which precautions are taken to secure a considerable slackening in the speed of the train when approaching its destination.

This effect is obtained by causing the air in front of the train to be compressed in the last hundred metres leading to the receiving apparatus; this compressed air is allowed to escape slowly in such a way that the train rises slowly into the apparatus.

Pneumatic lines with relays would certainly be a valuable means of communication for correspondence between distant places. The facility with which trains can be multiplied upon these lines without considerable expense, the speed which they can attain, and even the small net cost of the system, if too large a diameter be not employed, would make it one of the greatest utility to the Postal service.

The speed of transmission is three times that of the fastest railway train, if the stoppage of the latter are taken into account, and the establishment of the system upon lines where several days are required for exchange of letters, would evidently be of immense service.

A line of this kind has been proposed for establishing rapid communication between the Assembly at Versailles and the Ministerial offices in Paris; its execution would be a first step in this path, which is little known and which has been but little explored.

GATHERINGS FROM THE EDITOR'S NOTE BOOK.

"Now creatures in the likeness of men vent their despicable passions in murderous assaults upon women and children. But science hints at an effectual cure. It is probable that, before many years have passed, electricity, which by some mysterious means enables our nerves to call our muscles into play, which enables us to converse with one another at distances of thousands of miles, which alike plates the teaspoon and illumines the lighthouse, will be called upon by an enlightened legislature to produce absolutely indescribable torture (unaccompanied by wound or even bruise) thrilling through every fibre of such miscreants."—*The Unseen Universe.*

Wertheim, from an elaborate series of experiments, concluded that there is a temporary diminution in the co-efficient of elasticity in wires while they are transmitting currents, which is independent of the heating effect of the current.

Dufour found a notable diminution in tenacity in a copper wire through which a feeble current had passed for several days. In an iron wire the tenacity increased under similar circumstances.

Edlund has shown that wires are elongated when transmitting currents.

Cavendish showed that nitrogen and oxygen in air formed a mixture only, but that the passage of electric sparks produced their chemical combination—nitric acid being the result.

"Common air loses nearly all its resisting power at some temperature between that of boiling water and red hot iron, and conducts continuously (not, I believe as is generally supposed to be the case, by disruption), as glass does at some temperature below the boiling point, with so great ease as to discharge any common insulated conductor almost completely in a few seconds."—(Thomson.)

Faraday calculated that the decomposition of a single grain of water required 800,000 discharges of his large Leyden battery.

Buff finds the quantities of electricity associated with one milligramme of hydrogen in water to be equal to 45,480 charges of a Leyden jar, with a height of 480mm. and a diameter 160mm.

Weber and Kohlrausch have calculated that if the positive electricity associated with one milligramme of hydrogen in water were diffused over a cloud, at a height of 1000m above the earth, it would exist upon an equal quantity of negative electricity at the earth's surface an attractive force of 2,268,000 kilogrammes.

Faraday established the fact that gases are but the vapours of liquids possessing a very low boiling point.

Rankine has drawn attention to the odour of metals. Whence this odour?

Induced Current.—"It appeared as if the current, on its first rush through the primary wire, sought a purchase in the secondary one, and by a kind of kick impelled backward through the latter an electric wave, which subsided as soon as the primary current was fully established."—(Tyndall.)

Unpolarized electrodes are obtained by using amalgamated zinc and a weak solution of zinc sulphate. If there be free sulphuric acid, it should be neutralized by carbonate of zinc. Common zinc may also thus be used.

The coarse long hair from the neck of an old chamois if drawn between the finger and thumb, from the root to the point, becomes positively electrified, but if drawn in the reverse direction it becomes negatively electrified.

Glass, especially the hardest and best vitrified, is often a very bad insulator, sometimes being quite a conductor. Glass vessels made for electrical purposes are often rendered very good insulators by use and time, though they might be very bad ones when new.—(Cavallo).

A piece of wood cut from a tree is a good conductor; let it be heated and dried, it becomes an insulator; let it be baked to charcoal, it becomes a good conductor again; burn it to ashes, and it becomes an insulator once more.

THE TELEGRAPHIC JOURNAL.

VOL. III.—No. 65.

WEATHER-TELEGRAPHY.

EVERY science has in its time to pass through three stages before it can be considered perfect. There is first the stage of observation, when as many facts as can possibly be gathered together are duly marshalled in their proper order; next comes the stage of reflection, when theory steps in and adduces order from apparent disorder by explaining away the darkness hanging over these facts, and by unravelling the causes which have led to them; finally, there is the prophetic stage,—the phenomena of the past and present being satisfactorily accounted for, those of the future can be foretold with certainty.

There can be no question as to which of these stages Meteorology is in at the present moment. Many there are who would gravely doubt if it will ever get beyond the stage of observation, yet those who are best qualified to judge can entertain only one opinion upon the subject, and that is that our present ignorance and consequent wide-spread superstition with respect to it cannot last long. The weather phenomena must yield to that irresistible spirit of enquiry which never yet has failed in eventually surmounting whatever difficulties it has attacked. Thus Sir John Leslie, in his work on Natural Philosophy, says, "It cannot be disputed that all the changes which happen in the mass of our atmosphere, involved, capricious, and irregular as they may appear, are yet the necessary results of principles as fixed, and, perhaps as simple, as those which direct the revolutions of the Solar System. Could we unravel the intricate maze, we might trace the action of each distinct cause, and hence deduce the ultimate effects arising from their combined operation. With the possession of such data we might safely predict the state of the weather at any future period, as we now calculate an eclipse of the sun or moon, or foretell a conjuction of the planets."

To unravel this intricate maze by gaining possession of the data which are required, is the object of meteorology in its present stage. The initiative for this purpose in England was taken by the late Sir John Burgoyne, who as recently as the year 1852, proposed that land observations should be made by the Corps of Royal Engineers. Commodore Maury had been working at Washington for some time previously in the same direction, and the United States Government, on being consulted, expressed their entire willingness to co-operate in the scheme, and suggested that marine observations should be taken as well. Since then, the maritime nations have, one after another, taken up the idea, and throughout the whole civilised world at the present moment, not only are observers stationed at what have been considered to be the most advantageous points, but many of the steamship companies have lent their assistance to the work by allowing observations to be taken on board their vessels by competent observers with first-class instruments, and rendering these to the Meteorological Office upon their return.

To America belongs the credit of having been the first to suggest the employment of electric science, in the collection of these observations and in the utilisation of the results deduced from them when once obtained. As far back as the year 1846 we find Professor Redfield thus writing to the American Journal of Science and Arts: "In the Atlantic ports the approach of a gale may be made known by means of the electric telegraph, which probably will soon extend from Maine to the Mississippi," The idea thus originated was actually realised and carried into practical execution by Professor Henry and his assistants at the Smithsonian Institution between the years 1850 and 1855, and the subsequent impulse given to meteorology amongst the nations of Europe was unquestionably owing mainly to their exertions in this direction. In 1854 Le Verrier, in France, came to advocate the immense value of a system of telegraphic weather reports; whilst in 1861, in our own country, Admiral Fitzroy,—whose name will ever be inseperably associated with the science,—devised a code of meteorological telegraphy, instituted a regular service by means of which reports were received from various stations on the coast, and laid the basis of that weather study which, notwithstanding the innumerable difficulties it has to contend with, is day by day approaching a state of greater perfection. On the death of Admiral Fitzroy an able successor was found in Mr. Robert Scott, under whose direction the Meteorological Office in London is now conducted. Daily weather reports are there received by telegraph from no fewer than fifty-one stations, extending from Haparanda, at the extreme north of the Gulf of Bothnia, to Toulon, on the shores of the Mediterranean; from Christiansund, on the western coast of Norway, to Corunna, in the north-west corner of Spain, and including The Skaw, Wisby (the capital of Gothland), Paris, Biarritz in the S.E. corner of the Bay of Biscay, Sumburgh Head in the Shetland Isles, Valentia, Stornoway in the Hebrides, Hurst Castle in the Solent, &c., &c. The following particulars are sent from each of these at 8 a.m. daily:—The height of the barometer, the height of the thermometer in the shade, the direction and force of the wind, the amount of cloud, state of the weather, rainfall for the previous twenty-four hours and the sea disturbance. These are tabulated, and four charts, one for the barometer, another for the thermometer, a third for the wind and sea, and a fourth for cloud and rain, are drawn up from the data thus obtained, published and issued the same day. Incorporated with these are reports giving the same particulars at 2.0 p.m. on the previous day for nine stations.

Great as the service may be which electric science thus renders to meteorology in the collection of these observations, it renders a still greater practical service even now; and one which, as the science advances, will be more and more appreciated in giving timely warning of the approach of rough weather. For although no attempt has yet been made at a theoretical explanation of meteorological phenomena, there are certain valuable facts established from an observation of them. The motion and force of the winds, for instance, depend upon what has been named "the barometric gradient;" that is is to say, if there is a difference in the height of the barometer at any two places a

wind sets in between them with a force proportional to that difference; the area of depression again is found, as a generel rule, to travel eastwards at an average rate of about thirty miles an hour. Thus it is, that as most of the storms which visit us are first of all felt upon the western shore of Ireland, timely warning of the approach of these can be given to the seaports on the Irish Sea, the English Channel, the East Coast, as well as to France, and the eastern shores of the North Sea, all of which are warned of the expected approach of storms by our Meteorological Office.

The following statistics for the United Kingdom require no words added to them to show the good work done by our Meteorological Office in thus giving timely warning of the approach of nearly every serious storm to the seaport towns along the Coast:—

—	Warnings justified by subsequent Gales.	Warnings justified by subsequent Strong Winds.	Total Warnings justified.	Warnings not justified by subsequent Weather	Warnings late or partially late.
1870	46.7	21.7	68 4	22.4	...
1871	46.	17.7	63 7	22.	...
1872	61.	19.5	80.5	11.9	...
1873	45.2	34.	79.2	16.8	4 0
Totals for 1873	250	113	85	42	10

For this reason many suggestions have been made as to the best means of obtaining information of these storms on their easterly journey. The Portuguese meteorologists have proposed furnishing observations from the Azores by means of the cable, which touches there. This has been declined on the ground that no connection can be discovered between the movements of the barometer at Valentia, our most westerly point of observation, and the Azores. The storms which pass over these islands take a south-easterly direction towards the African continent, and do not seem to approach us. Equally valueless was the proposal to receive information from the United States, for the character of the storms becomes entirely changed after travelling over any considerable area of the earth's surface. The idea of placing large buoys as advanced points of observation off the Irish coast, and connecting them by wire with the main-land must likewise be abandoned until some means of anchoring these in such deep waters have been devised.

In another important respect electrical science brings with it valuable aid to the science of meteorology. No great meteorological change takes place without its being accompanied by marked disturbances in terrestrial electricity, either in the air, in the earth, or in both. And simultaneous observations of these disturbances carried out in different quarters of the world, and now for the first time rendered possible by the development of electrical science would place in our hands the only means by which we can hope to get at some definite understanding respecting them. The theory of lightning and thunderstorms is now fairly understood: the aurora borealis, it is generally accepted, is the result of electrical discharges through the rarified strata of our atmosphere, comparable in every respect to the passage of electricity through the so-called vacuum tubes. The earth currents, on the other hand, which are constantly flashing to and fro through the crust of our globe, but which at times appear with far greater violence than at others, are still unintelligible, and have in fact only of late years commanded the attention which they merit: the cause of the changes in terrestrial magnetism is likewise still wrapt in mystery.

Yet, notwithstanding the many barriers which stand in the way, "no philosphical mind," to quote the words of Dr. Whewell, "can doubt the fixity of these rules which are followed by the causes ever at work in producing those changes of winds and skies." And when the day does come, as come it inevitably must, when these are perfectly understood, only then can the aid which electric science has rendered be fully recognized.

ON A SYSTEM OF TELEGRAPHY.

A Course of Lectures, delivered at the School of Military Engineering, Chatham,

By W. H. PREECE, Member Inst. C.E., &c.

Lecture II.—A System of Telegraphy as applied to Commercial Purposes.

(Continued from page 213.)

We may take it for granted that in any invaded territory, where the commercial relations of its different localities have been conducted by telegraph, as is the case now amongst all civilised nations, these telegraphs must be continued in operation by the invaders to maintain these relations for the supply of food and necessaries to the armies, and for the support of the populations. It was so in France. The Germans had to invade all the occupied Departments with their telegraph organisation, and under certain necessary military restrictions, a complete commercial system was maintained. Hence it becomes necessary to discuss a system of telegraphy in its application to commercial purposes.

The same outcome of experience, the same process of natural selection, the same operation of the principle of the survival of the fittest, which have characterised the establishment of a railway system, are to be observed in the formation of a commercial system of telegraphy in England.

I pointed out in my first lecture that the first use of the electric telegraph in England was to facilitate the movement of traffic on railways. Prior to 1844, several short lengths of telegraph were erected upon different railways for this purpose, but it was in 1844 that the first line of any length was constructed, which was from London (Nine Elms) to Gosport, upon the London and South Western Railway. It was in reality erected under the auspices of the Government, for the Admiralty undertook to pay £1,500 a year for 20 years, and £1,000 a year for a further 20 years, for the maintenance of a double needle telegraph, for their own purposes, between Whitehall and Gosport and Portsmouth. The railway company

found the capital, and Messrs. Cook and Wheatstone carried out the work. In 1846 a company was formed to purchase the interests of Messrs. Cook and Wheatstone, and to establish a commercial system of telegraphy. The railway companies generally had begun to learn the advantages of the telegraph. The telegraph company undertook the erection and maintenance of wires, and by agreement, mutual arrangements were made by which the service was performed by the telegraph company. All the principal railways were rapidly fringed with wires. The service being a joint one the same wires conveyed both public and railway messages. The commercial prosperity at first was very poor; the returns were very small, and the prospects of the speculative shareholders very discouraging. In the year 1851, although 198 stations were open to the public, the total number of public messages sent during the twelve months was only 48,490. Ten years later they reached 2,676,354. As the public messages increased, they interfered so much with the service messages on the railway companies' business, that separate wires had to be erected for the public traffic, so that the principal centres of manufacture became connected with London by purely commercial wires, and similarly as the necessities of the railway service increased, it was found advisable to maintain wires purely for railway purposes. Hence, gradually two distinct systems began to form themselves side by side—the commercial system for public messages, and the railway system for the transaction of railway business proper. In 1870 these two systems became totally separated and rendered perfectly distinct from each other by the assumption of the commercial telegraphic business of this country by the State. In fact the time had come for such a step. The natural consequence of great commercial prosperity had shown itself. Rival and competitive companies sprang up to share with the successful introducers of commercial telegraphy their well earned profits; competition and emulation stepped in with all their beneficial advantages to the business section of the public, but at the same time carrying with them all their unprofitable results to a too confiding investing public.

The railway companies had found the necessity of distinct systems of their own for the furtherance of their own business, and the general public began to find that telegraphs were not useful for speculation alone but were adapted to play a far higher and more national object. The wires have now become the vehicle of communication as much for our little household joys as for the great concerns of state. The telegraphs belong to the nation, and every person has an interest in their wellbeing and welfare.

Year.	Miles of Wire.	Number of Stations.	Number of Messages.
1851	7,303	192	48,490
1862	57,879	1 616	2,676,354
1873	105,572	5,560	17,103,844

In 1849 there were but eight instruments at the head telegraph office in London, worked by four or five boys, there are now 436 instruments, employing 682 females, and 761 males, 1,443 in all. In 1852 it was mentioned as an extraordinary fact, that 1,000 messages passed through this office in one day. On August 1st, 1863, there were no less than 31,455, not including press work, which amounts to about half a million words every 24 hours.

The enormous development of telegraph business since the transfer to the State is due not only to the reduction of the tariff, but to the extension of the system to those numerous small post offices which private companies based on commercial principles could never have reached, to the increased facilities offered to the public, and to the improved manner in which the messages are transmitted as regards rapidity of despatch and accuracy of transmission.

I can remember the time when messages cost 6d. and 8d. *a word*. They are now less than three farthings. Addresses are sent free, occasionally much to the discomfort and loss of the postal department For instance, a message was sent from Sherborne, and delivered to "Jim Pierce, a little boy in charge of a horse and gig in a field called eight acres just above railway station, belonging to Mr. Giles Farrington Gurney." Another was to "F. T. Gleeson, a young American gentleman visiting the Tower of London, care of the presiding officer, London Tower. N.B.—Has peculiarly curly hair." Both were delivered. Another was addressed and delivered to "two ladies standing on the steps of the Royal Exchange."

The earlier telegraphs were all erected overground upon the railways. The mutual understanding existing between the first telegraph company and the railway companies facilitated this arrangement. The wires were carried into the towns underground. In a few exceptional instances only, where railways did not exist, poles and wires were carried along the roads by the side of the canals or across the country. But when rival companies sprang into existence, desirous of establishing communication between great centres of commerce already connected by the first telegraph company in possession of the railways, they were forced to take possession of the roads and canals. Hence when the telegraphs passed into the possession of the State, two great systems were found to be in existence—the one occupying the railways, and the other the roads and canals.

Owing to the opposition which the railway companies offered to the Bill to acquire the telegraphs in its passage through the House of Commons, a compromise was effected with the companies by which they retained the maintenance and management of the telegraphs on the railways, whether they were employed for postal or for railway work, but the road and canal lines remained in undisturbed possession of the Post Office. Hence there still remains two systems, the one—the road system, under the entire management of the Post Office; the other—the railway system, maintained by the railway companies, under the supervision only of the Post Office.

The relative advantages of road and railway wires are worth discussion, for the first question the telegraph engineer has to decide when erecting a telegraph is the selection of the best route. Although the first cost of the erection of a telegraph on a road is greater than on a railway, its subsequent maintenance under certain conditions is less. The principal condition is that the railway skirts the road so that they both run in the same direction, by which means access from one to the

other is easy. We thus obtain the conveniences and facilities of the road together with the conveniences and facilities of the railway. Under such conditions, carriage of stores is simple, the supervision of the line is more perfect, for the fact that the poles run along the side of a road induces better inspection. The inspector cannot help closely inspecting every wire and insulator. Little imperfections are easily detected and removed before they have time to become injurious. Prevention is better than cure at all times, and more especially so in a line of telegraph. The road man must walk his length. Even if he begs a ride he cannot go too fast to inspect his wires. It is not so on a railway. Walking is very difficult and it is neglected. The railway man contents himself with the train, from which close inspection is impossible.

The reparation of faults is speedier upon roads than upon railways. The road man is able to start after a fault *at once*, while the railway man has not only to wait for the starting of a train, but has frequently to pass the fault, and has to return to it many miles on foot. Hence experience proves that wires on roads are better maintained than those upon railways, the number of faults is less, and their duration not so great. It is generally assumed that a road line is more liable to wilful damage than that on a railway, but experience does not confirm that assumption. Insulator breaking is one evil which is met with on roads, but it has been considerably checked. Cockshying is a very healthy and amusing pastime, but it is speedily cured by immersion in a lock-up.

Each telegraph company as it sprang into existence was projected principally to utilize the patents of different inventors. Thus the original electric telegraph company acquired Cooke and Wheatstone's Patents. The British Company worked Highton's Patents; the Magnetic Company worked Henley's and Bright's Patents; the United Kingdom Company acquired Hughes' Patents; the Universal Company used Wheatstone's later patents, &c. Each company acting on its own experience had determined the best form of apparatus for its own purposes. Many kinds had been jostled out of existence by more fitting opponents, but there still remained many varieties. When all these companies passed into the possesion of the State, it became a subject of grave consideration to determine which forms of apparatus should be selected from the variety at the disposal of the department.

The form of instrument to be employed, expressly in a commercial telegraph, is a point of fundamental importance. Telegraphy does not convey ideas *directly* by signs or symbols, hence it is not a language. It merely transmits to distant points the first elements of a *written* language by certain preconcerted signals. Letters or numbers are indicated by signals which are either *visible* or *audible*. The visible signals are either transient or permanent and differ in *form* or *duration*. The audible signals are necessarily transient, and they differ in *tone* and *duration*.

The earliest form of an electrical instrument devised was one which indicated directly the letters of the alphabet by five pointers, but that first introduced into commercial use was the double of Cooke and Wheatstone, whose inventions the first electric telegraph company was projected to utilise. The needle telegraph is based on Romagnosi's discovery of the mutual action of a current and the magnet. Its signals are visible, transient, and different in form. The alphabet is formed by the vibrations of two small movable pointers or needles between two fixed spots. Two wires are required for its use, one of these wires so frequently failed that a single needle alphabet speedily shaped itself. Hence the practical teaching of actual experience reduced the *five* needle instrument first to *two* needles and then to *one* needle. The double needle instrument is now an instrument of the past, there is but one left in the Postal Telegraph Department, and it is gradually being replaced on the railways by the more convenient single needle. The single needle is a very useful form of telegraph. It is exceedingly simple in its construction, it is little liable to get out of order, it requires no adjustment or alteration of its parts to meet the varying changes of the weather, and its manipulation is easily acquired. Its chief advantage for railways is the fact that numerous instruments can be inserted on one circuit. Hence all the small intermediate stations of a long line can be served by one wire. Indeed it being the fittest for railway purposes, it has survived all other forms, and it remains essentially a railway instrument.

The tendency of improvement has been to lighten all its parts, and to increase its rate of working. The earlier double needle instrument only averaged *six* words per minute, but upon the later forms *forty-five* words per minute were easily attained by experienced manipulators. Even the single needle attains *thirty-five* words per minute. Hence wires which in the earlier days could convey only *six* words now transmit *seventy* words per minute.

The lessons of experience are admirably shown in the variations which the form of this apparatus and its parts have undergone during its existence of a quarter of a century. I can conceive no better way of instruction in the relative advantages and merits of different forms and parts of an apparatus than an examination of the different stages of its life; and I think that every telegraph school should be supplied with different specimens of each instrument in the various phases of its creation.

In America Morse had invented his recording instrument with its dot and dash alphabet, in fact a telegraph with visible signals, permanent in their character and differing in their form. The permanent marks were embossed on paper by the attraction of an electro-magnet upon its armature forcing a style against the paper strip. It only required the use of one wire and the operators were able to write for themselves. The needle instrument required a writer, unless indeed satisfaction was felt with reduced speed, for on the needle instrument, if a clerk has to read and write for himself, he has two operations of nearly equal duration to perform, the one to read the word and the other to write it down, hence the speed of working must be reduced one-half. Bain, in England, in 1846, invented an instrument similar to that of Morse, which recorded its dots and dashes by the precipitation of Prussian blue upon chemically prepared paper on the passage of the currents through it. This latter form was adopted in England in preference to Morse's original form, but about 1862 it was supplanted by the true

"Morse," which was less liable to get out of order, and which avoided the troublesome operation of preparing paper chemically, and which has recently been still further improved by supplanting the embossed paper with a pen, which records its character in ink.

This later form of apparatus is in very general use throughout Europe, but it is not the fittest, and it will probably not survive other forms which are developing themselves.

The speed with which an instrument works is usually registered by the *number of words* it can transmit in a *minute*, but owing to the regularity with which messages retain their average number of words, *the number of messages* transmitted *per hour* is now the usual criterion. Messages average 35 words, and words average 4·5 letters. Hence roughly, half the number of messages per hour equal the words per minute. The earlier Morse could not exceed six words per minute, but the rate at which the instrument now works on short circuits is simply the rapidity with which the operator can manipulate his key; 70 messages per hour are frequently obtained by experts, but it is difficult to maintain such a speed. The human machine tires, errors occur. His manipulation loses clearness and legibility. Bain invented the automatic apparatus to replace the human machine by a mechanical contrivance. This secured precision in the formation of the characters, accuracy in the despatch of messages, and speed in the transmission of work. There were, however, defects in Bains' apparatus, and automatic telegraphy was not a success until Sir Charles Wheatstone introduced his beautiful apparatus which is now in such extensive use, and without which it would have been impossible for the Postal Telegraph Department to meet the requirements of the press.

(To be continued.)

The electric telegraph system is still in its infancy, and although its operations are marvellous, yet it is probable that we are at present but imperfectly acquainted with the full extent of its advantages. In this country the telegraph wires are simply used for the transmission of messages, but to Armenia belongs the honour of discovering that they may be adapted as clothes-lines for laundry purposes. The practice of hanging linen to dry on the wires has lately become general in that country, and revealed the hitherto unknown fact that the Armenian peasantry are in the habit occasionally of washing their clothes. Much dismay has, however, been caused by an order that has been issued by the authorities forbidding the continuance of this arrangement. It seems that the wires have on more occasions than one been broken by awkward washerwomen, and Shefket Effendi, an Armenian Scudamore, who has just been appointed director of the telegraph at Erzeroum, has solemnly declared that no more shirts, stockings, or other garments shall be hung on the wires on any pretence whatever.

Professor Cornu, of the *Ecole Polytechnique*, Paris, has put into successful use a new inatrument for measuring the velocity of light between two stations, in which an electrical registering apparatus is used, giving, it is believed, more accurate measurements than the well known toothed wheel arrangement of Fizian. Foucault fixed the velocity of light, by his instrument, at 185,157 miles per second. Professor Cornu, by his new instrument, fixes the velocity of light at 186,660 miles per second, 1,503 miles faster per second than Foucault.

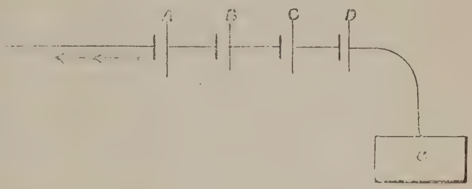
ON THE TELEGRAPHIC PROBLEMS OF DOUBLE SENDING AND QUADRUPLEX TELEGRAPHY.

By G. K. WINTER,
Telegraph Engineer to the Madras Railway.

(Continued from page 219.)

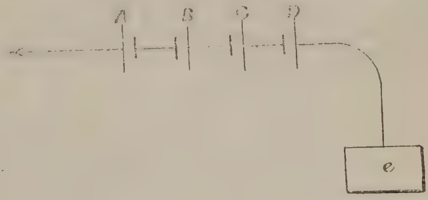
There are several ways of accomplishing this; perhaps the best is as follows:—

Let us suppose the full battery to consist of four cells (any multiple of that number would do as well). Let us represent them thus:—



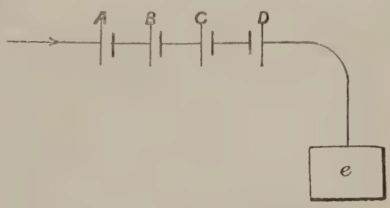
Let this be supposed to give two units of copper current to line.

Now suppose one of them, A, to be reversed by a reversing key, we shall have—



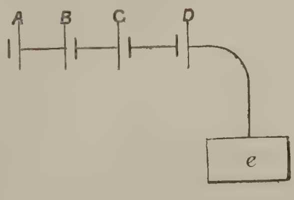
thus A and B neutralize each other, and we shall have one unit of copper current to line.

Next let us suppose A B and C to be reversed by the depression of the other key, then we shall have—



or one unit of zinc current to line.

Lastly, let us suppose both keys depressed, then A, which is reversed by the first key, will be set right again, and we shall have—



or B and C will neutralize A and D, and we shall have no current to line.

The following figure is a conventional mode of

representing the action of reversing keys, and will doubtless be understood.

r and r^1 are adjustable resistances, and I think the rest explains itself.

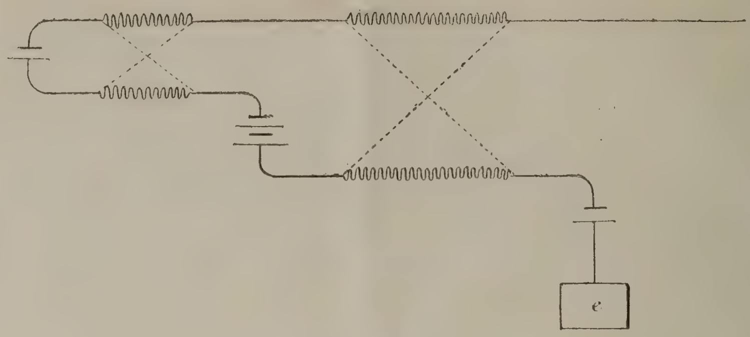


Fig. 8.

The sinuous lines show the connections when the keys are at rest, and the dotted lines shew them when they are depressed.

We have now to show how this system may be made into a quadruplex system by the application to it of the duplex principle. There are two ways of doing this, perhaps in practice the following will be found the best:—

With regard to adjustments, let a galvanometer **G** be inserted as shown in fig. 9, request the distant station to depress his key B, then adjust r until depressing either of your keys makes no alteration in the deflection of your galvanometer. This being done, adjust r^1 until the deflection itself becomes nil.

There are two or three obvious modifications of

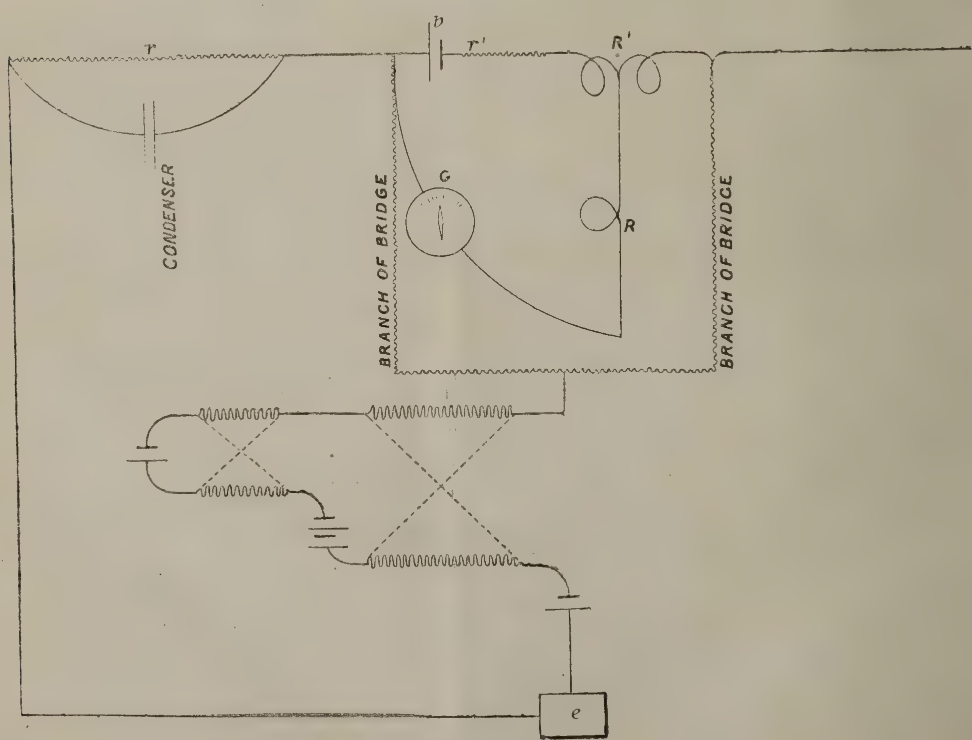


Fig. 9.

the arrangement of the receiving apparatus. For instance, we may connect the two relays one after another in such a way that the tongue R will be worked by a copper current from the distant station, while those of R¹ are worked by a zinc by the adjustment of the position of the tongues between the poles of the electro-magnets. We sacrifice, however, by these modifications, the very simple means of adjusting the arrangements which we have just described.

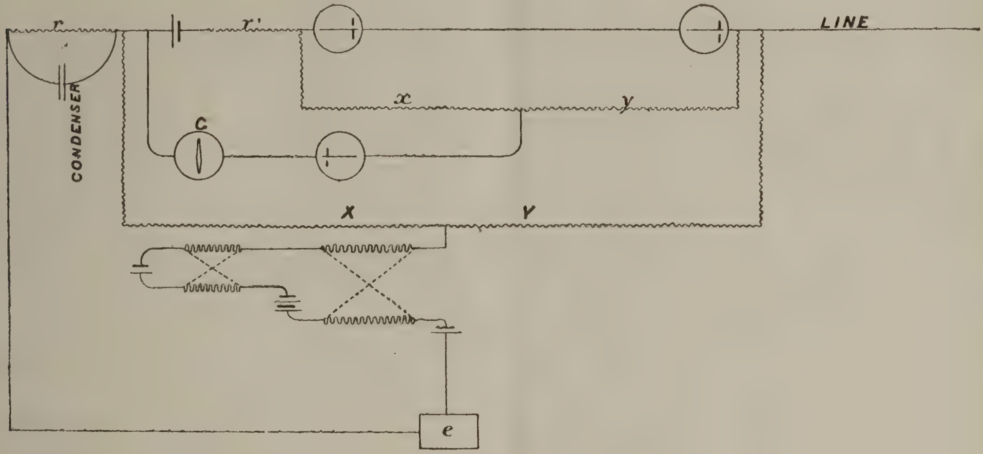


FIG. 10.

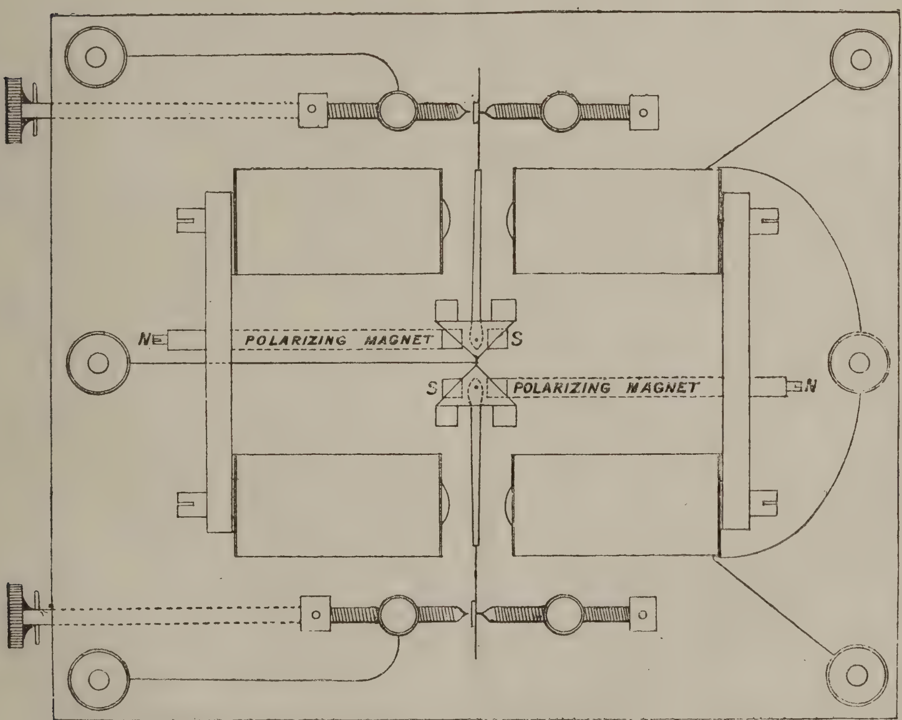


FIG. 11.

current, and then having the local battery connected through extra coils wound on the relays, and in each case tending to cause the tongues to make contact with their respective contact points; or we may abandon the local battery altogether, and substitute a bias in favour of making a signal

The following is a modification, however, which will probably prove an improvement in some respects. Instead of winding the relay R¹ differentially we may substitute the Wheatstone bridge principle, and further, we may use two distinct relays instead of one relay with two tongues. This

modification will enable us to place the two relays by means of which signals are produced upon Morse A, near that instrument, so as to be kept in adjustment by the clerk attending to it; while for the same purpose the other relay may be placed near the Morse B. The arrangement under this modification is shown in fig. 10, in which x and y are the branches of the last-named bridge, and X and Y the branches of the bridge for making the system a duplex arrangement.

We may also, even while using two distinct relays instead of a relay with two tongues, wind each of them differentially instead of using the branches x and y, but the bridge arrangement has certain advantages which leads me to prefer that system.

The form of double tongue relay that I have used for this arrangement is simply an adaptation of the relay used in applying my duplex method to intermediate stations. It is shown in fig. 11.

The double sending arrangement described in this paper has been worked with perfect success between Salem and Madras, on the Madras Railway, a distance of 206 miles. The arrangements for quadruplex working are not yet completed, but feeling sure, that having proved the success of the double sending, the success of that system worked in duplex may be taken for granted. I have not thought it advisable to delay this paper until the quadruplex system was in actual operation.

APPLICATION OF THE MAGNETIC NEEDLE IN SEARCHING FOR IRON ORE.

The discovery of a considerable portion of the new mines in Sweden has been due to the facility of observing their action on the magnetic needle.

From the *Journal de Physique*, we learn that M. Thalen has recently conceived the idea of employing the magnetic needle not only to find the existence, but also, to a certain extent, the strength or quantity, the direction and depth below the surface, of masses of ore. M. Thalen effects this by measuring the intensity of the magnetic action, or rather of its horizontal component, at a series of points as near, and at as regular intervals as possible over the supposed mine. This measurement is made with a declination needle, and with the aid of a movable magnet which the observer can, at will, place in a fixed and invariable position with regard to the needle, or to remove it. At each point of observation, the needle is first brought to zero, the magnet being withdrawn. The magnet then being placed in its position, the angle of deflection is observed. The measure of the intensity of terrestial magnetism, comprising that of the ore below the soil, can be easily deduced. A certain number of observations enable the observer to trace lines of equal intensity, called *isodynamic lines*, which are found to be disposed in two series of closed curves, surrounding with greater or less regularity the two points, which correspond to the greatest and the least deflection of the needle. Between these two series of lines is a line not closed, called the *neutral line*, and which corresponds to points where the the magnetic influence of the mineral is *nil*.

The conclusions at which M. Thalen has arrived, are:—The line which joins the maximum and minimum, and which may be taken as the magnetic meridian of the mine, indicates the general direction of the ore. The intersection of this line with the neutral line denotes the point at which it is preferable to commence operations. And, lastly, the distance from this latter point to that of the magnetic meridian of the place, for which the deflection is minimum, gives half the distance from the centre of the mass of ore to the surface. These two latter results are only applicable, if the depth of the ore under the surface is considerable.

ON TELEGRAPH CONSTRUCTION.

By JOHN GAVEY.

Iron wire, as is well known, has hitherto been almost wholly used for the conductor of an open line of telegraph. Although offering a much higher resistance to the passage of a current of electricity than a copper wire of equal section would do, its superior tensile strength, and its cheapness as compared with the latter, have caused it to be universally employed.

It is very important for many reasons that iron of a good quality alone should be used, hence wire specifications generally contain very definite stipulations as to the tests which it should withstand with success. Hitherto none but its mechanical qualities have been regarded, it being doubtless considered that the difficulty and expense involved in the electrical testing of long lengths of iron wire, would be greater than the advantage to be derived from the introduction of a standard of electrical conductivity for each gauge. Iron like all other metals, varies much in its electrical resistance, according to the state of purity in which it may be obtained. Inasmuch, however, as uniform mechanical qualities are insisted upon in purchasing wire for telegraph purposes, and these qualities depend, to a great extent, on the state of purity of the metal, the per centage of variation in the conductivity of various lines, is not so great as it might be, were the conditions of the contracts less stringent than they usually are. That the resistances do vary, however, is shown by the different results given by wires erected at different periods with varying classes of metal.

The manufacture of iron wire is a very simple, but very interesting process. In the first operation—that of rolling—a bar of malleable iron, about 2 feet 6 inches to 3 feet long, raised to a welding heat, is passed rapidly backwards and forwards through a series of rolls which contain grooves, varying by regular increments from three inches to one-fourth of an inch in diameter. At each passage the iron bar becomes less in diameter and increases correspondingly in length, until in the course of a few seconds it issues from the last groove, whence it is wound on a drum, and appears in the form of a coil of wire of somewhat large gauge. The whole operation is performed at one heating of the original mass.

The wire in this state is hard and brittle, and the next process is that of annealing. To effect this the coils of wire are enclosed in a kind of air-tight furnace, in which they are exposed to a considerable temperature, then cooled gradually. They are thus rendered soft and pliable and are in a fit state for drawing.

The drawing is a very simple operation. A

number of plates of steel perforated with conical holes are fixed vertically on convenient benches, opposite to which are revolving drums of iron. A coil of the rolled annealed wire is taken, one extremity by a few dexterous blows with a hammer is reduced sufficiently in size to admit of its passing through the first hole in the draw-plate; it is then seized by a pair of tongs attached to the drum, which latter being put in rapid motion, the wire is drawn through the plate, and reduced to a uniform diameter, equal to that of the hole through which it has passed. This operation is repeated as often as is necessary, using smaller gauge draw-plates successively until the requisite size of wire has been obtained. For telegraph purposes the wire is annealed after the drawing is complete.

The final operation is that of galvanizing. To effect this the iron is first thoroughly cleansed in a caustic lye, to remove the grease which adheres to its surface in drawing. It is then immersed in a bath of *pickle*, composed of hydrochloric and sulphuric acids, to remove all traces of oxide, and to leave a chemically clean surface. After being washed in pure water to remove any adhering acid, it is finally passed through a bath of melted zinc, the surface of which is covered with ammonium chloride. The zinc unites with the clean surface of the iron, and on emerging from the bath, the wire is run through a bank of sand, which cleans off the superfluous zinc, and leaves that smooth bright surface which new galvanized iron presents.

Galvanized iron is invariably used for telegraph purposes in England, although in some countries plain iron wire is employed. The preservative action of the zinc covering arises from the formation of a coating of zinc oxide on its surface. Being insoluble in water, this coating protects the remainder of the zinc, and consequently the iron from further oxidation. In smoky places, however, the sulphuric and other acids, which are developed by combustion, attack the oxide and form sulphate or other like salts of zinc. These salts being soluble, are washed off by the first shower of rain, and a fresh surface of zinc is exposed to like influences, the result being that the whole of the coating is rapidly destroyed, and the oxidation of the iron of course follows. For such localities the wire is frequently protected by being coated with hemp or tape saturated with bituminous compounds. A simple application of coal tar, followed by dusting over the wet surface with clean sharp sand has been found effective; the difficulty with this is, however, to keep the protecting covering unbroken, for at all places where the metal is exposed rust sets in, which ultimately causes a break in the wire.

A compound conductor, consisting of a steel wire, covered with copper, has within a few years been used in America. A high conductivity with small bulk, and consequently, diminished strain on all supports is thereby attained. But little experience of its value in this country has yet been obtained.

The size or gauge of wire is denoted by numbers which correspond with various diameters. These numbers are entirely arbitrary, and several gauges are in use. That most commonly employed in this country is known as the Birmingham wire gauge. The following table, extracted from Mr. Culley's well known "Handbook of Practical Telegraphy," gives valuable information as to the section, weight, and breaking strain, of various sizes:—

IRON WIRE.

Birmingham Wire Gauge.	Diameter.	Area of Section.	Weight of 100 yards.	Weight of 1 mile.	Breaking Strain.	
					Hard wire.	Soft wire.
	inches.	sq. inch.	lbs.	lbs.	lbs.	lbs.
00	0.363	0.103	102.00	1,794	8.600	6.000
0	0.331	0.086	84.72	1,490	7.100	4.750
1	0.300	0.071	68.75	1,210	6.000	4.000
2	0.280	0.062	59.90	1,054	4.850	3.400
3	0.260	0.053	51.65	909	4.000	2.900
4	0.240	0.045	44.00	775	3.400	2 500
5	0.220	0.038	37.00	651	2.950	2.200
6	0.200	0.031	30.56	538	2.500	1.800
7	0.185	0.0265	26.15	461	2.200	1.520
8	0.170	0.023	22.10	389	1.750	1.200
9	0.155	0.0195	18.36	323	1.500	950
10	0.140	0.016	14.97	264	1.200	820
11	0.125	0.125	11.95	211	820	650
12	0.110	0.010	9.24	163	710	510
13	0.095	0.0071	7.05	124	640	400
14	0.085	0.0057	5.51	97	510	350
15	0.075	0.0044	4.29	76	410	300
16	0.065	0.0033	3.22	57	350	200
17	0.057	0.0026	2.48	44	280	150
18	0.050	0.0020	1.91	34	200	115
19	0.045	0 0016	1.55	27	150	85
20	0.040	0.0013	1.22	21	110	65
21	0.035	0.0010	0.94	17	85	50
22	0.030	0.0007	0.69	12	65	40

On account of the indefinite and varying sizes, which frequently correspond with certain gauge numbers, the diameters of wires are often given in decimals of an inch where accuracy is desirable.

In preparing specifications for telegraph wire, the following points generally are insisted upon:—It should be free from scales, flaws, splits, inequalities, cinder, and other defects, should be cylindrical throughout, and should conform within certain specified limits to the diameter ordered. Specimens from certain coils, either to be gauged with a decimal scale, or 10 feet lengths to be weighed, and the limits of variation to be defined. It should be highly annealed, soft, and pliable, and should stretch 18 per cent. without breaking. The wire should be manufactured in certain definite lengths, varying according to the gauge, which lengths should be entirely free from welds or joints of any description. Tensile strength and ductility to be specified. The former to be measured by the direct application of weights, the latter by gripping a certain length, say six inches between two pair of vice, and counting the number of twists it takes to break the wire. In this country it is customary to *kill* or slightly stretch wire before use. This is sometimes done in the factory by running the wire from one drum to another slightly larger in diameter, both being geared to revolve at the same axial speed. This removes all bends and kinks in the wire, giving it a smooth regular appearance, which not only improves the look of the line when erected, but causes a lesser liability to interruption from wind contacts. Flaws and bad places are likewise detected by the operation, which might otherwise pass unnoticd until they caused a fault through breakage when in actual

work. As a further means of revealing incipient defects the wire is frequently passed over and under a series of pulleys, by which splits and hard brittle places are revealed.

Notes.

The ordinary general meetings of the Society of Telegraph Engineers will recommence on the 10th November.

It is stated that the President of the Society, Mr. Latimer Clark, will give the annual soirée towards the end of November.

Mr. W. T. Henley has offered his unsecured creditors 7/6 in the pound, payable at three intervals, but we are not aware of any arrangement yet having been come to.

The first section of the New Zealand Cable has left for its destination, it is expected the cable will be completed by February. Mr. W. Grigor Taylor, of the Eastern Telegraph Company, leaves shortly to take charge of the line

The half-yearly meeting of the Anglo-American Telegraph Company was held on October 1st, at the London Tavern, Bishopsgate; Lord Monck in the chair. The report stated that the total receipts from the 1st January to the 30th June, 1875, including a balance of £3,683 11s. carried over from the last account, amounted to £288,636 18s. 7d. The total expenses of the half-year, including income tax, repair of cables, and depreciation of cable stock, amount to £47,570 11s. 7d. One quarterly dividend at the rate of 5 per cent. per annum, free of income tax, was paid on the 1st May, 1875, absorbing £87,500, leaving a balance of £153,566 7s. from which a second quarterly dividend at the same rate of 5 per cent. per annum, amounting to £87,500 was paid on the 1st August, 1875, leaving a balance of £66,066 7s. (including £32,301 11s. surplus cable) to be carried forward to the next account. The falling off in the traffic receipts for the first six months in 1875, as compared with the corresponding period in 1874, amounting to £67,729, is to be attributed partly to the continued depression of the American trade, but chiefly to the reduction of the tariff to 2s. per word, which came into operation on 1st of May, 1875. This reduction, announced in the last report of the directors, and unanimously approved by the proprietors at their meeting in April, resulted in a considerable dimuninution of receipts. The hopes which were entertained by many that low rates would produce remunerative results have not been realised, for, although a large increase in the number of messages was obtained, the experiment, so far, seems to show, on the contrary, that a low tariff cannot produce a reasonable dividend. The report and accounts were adopted unanimously.

Information has been received by the Cuba Submarine Telegraphy Company (Limited), of the successful laying of the new cable of the International Ocean Telegraph Company between Key West and Punta Rassa, whereby uninterrupted telegraphic communication with the West Indies, Demerara, and Panama is again established.

The Eastern Telegraph Company (Limited) announce the payment on the 14th October of an interim dividend of 2s. 6d. per share for the quarter ended 30th June last. The registers of transfers will be closed from the 7th to the 14th October, both days inclusive. The company also announce that the coupons on the Six per Cent Debenture Bonds will be paid on the 15th October next at the bank of Messrs. Glyn, Mills, and Co., Lombard-street, E.C.

The half-yearly report of the Eastern Extension Telegraph Company has been issued. It states that the balance of profit amounts to £82,280 3s. 6d. An interim dividend of 1½ per cent. has already been paid, and the directors now propose a further distribution of 1½ per cent., leaving £22,355 3s. 6d. to be carried forward. The debenture debt has been reduced by £3,200, leaving a balance of £4,700, of which a further sum of £1,500 has been redeemed since the commencement of the present half year. The greater portion of the debentures authorised at the meeting in June last for the purpose of laying the cable between Sydney and New Zealand has been taken up, and this undertaking will be completed early next year.

It is announced by the Globe Telegraph and Trust Company (Limited) that the interim dividends for the quarter ending the 18th inst. will be 3s. per share on the preference shares, and 3s. per share on the ordinary shares, both payments being at the rate of 6 per cent. per annum.

The traffic receipts of the Western and Brazilian Telegraph Company (Limited), for the five weeks ending the 1st inst., were £10,360, showing an increase of £1,124 over the corresponding period of last year.

The Brazilian Submarine Telegraph Company (Limited) announce that the accounts show a profit for the year ending 30th June sufficient to enable the directors to recommend a final dividend of 2s. 6d. per share, making, with previous distributions, 5 per cent. per annum, and carrying to reserve the sum of £40,000.

The board of the West India and Panama Tele-

graph Company (Limited) will recommend to the shareholders at the approaching general meeting the declaration of a dividend of 7s. 6d. per share on account of arrears of dividend on first preference shares to 30th June, 1875.

We understand that the Silicated Carbon Filter Company, Battersea, have received an order from the Indo-European Telegraph Company, Kurrachee, for a supply of their largest sized filters, for use at the various stations along the route. Filters upon this principle have been in use for many years at the General Post Office in London, and they have also been adopted by the telegraph department and several other branches of the public service.

The Western and Brazilian Telegraph Company announce that their cable is interrupted between Santos and Santa Catherina. The breakage is in very shallow water, and their repairing ship being on the spot, communication by cable will be restored in a few hours. In the meantime telegrams for the south will be transmitted over the Brazilian Government land lines in operation between Santos and Santa Catherina.

The number of messages passing over the Cuba Submarine Telegraph Company's lines during the month of September was 2,072, estimated to produce £2,000, against 1,797 messages, producing £1,802 in the corresponding month of last year.

The traffic receipts of the Direct Spanish Telegraph Company, Limited, for the month of September, amounted to £1,547, against £1,245 last year.

The traffic receipts of the Submarine Telegraph Company for the month of September amount to £10,013, against £9,682 for the corresponding month of last year.

The traffic receipts of the Great Northern Telegraph Company for the month of September amounted to 392,089f., against 425,931f. last year; and the total traffic receipts from 1st January to 30th September were 3,186,948f., against 3,328,040f. last year.

The traffic receipts of the Eastern Telegraph Company for the month of September amounted to £30,176, against £28,208 in the corresponding period of 1874; those of the Eastern Extension, Australasia, and China Telegraph Company (Limited) to £48,080, against £18,163 in 1874; the Brazilian Submarine Telegraph Company (Limited) to £9,544, against £8,238; and the Direct Spanish Telegraph Company (Limited) to £1,547, against £1,245.

The Submarine Cables Trust announce that the coupons for the half-year, due on the 15th instant, will be paid as usual by Messrs. Glyn, Mills, and Co., on and after that date.

Within a few days of the opening of the Direct United States Cable, it was officially announced that it was interrupted. The fault is stated to be in shallow water off Newfoundland. The Faraday is expected to leave immediately in order to restore communication.

The working of the Direct was very good, and a high speed maintained. The Company claim to have delivered messages in New York in less time than the Anglo-American Company.

Immediately after this interruption the Anglo-American Company announced an increase in tariff to 4s. per word, which rate, it was stated would remain unaltered in the event of the Direct Cable being repaired.

It will interest our readers (says the *Indian Daily News*) to learn that "Quadruplex Telegraphy" (that is, the art of sending four messages, two in each direction, simultaneously, by means of one wire) has this week been accomplished on the Madras Railway Telegraph. The system which Mr. Winter, the telegraph engineer, invented in March last, proved perfectly successful on eighty miles of line, and its extension to lines of greater length is simply a question of additional condensers and battery power. The principle of sending two messages simultaneously in the same direction, on which this quadruple system depends, was successfully worked between Salem and Madras on the 16th of April last, but unfortunately other duties prevented Mr. Winter carrying out the duplexing of this principle until the last few days.

Since the nomination of Yaver Pacha as Director of the Telegraph and Postal Department and Mr. Scudamore's arrival, the postal and telegraphic administrations have displayed great activity. Yaver Pacha has introduced several important modifications in the interior postal service, and is now endeavouring to organize a daily mail for the rest of Europe, viâ Yaneonleon and Bucharest. There is every reason to believe that the Turkish administration will undertake the international service on the 1st January under the best conditions.

An interesting account of the preparation of the daily weather reports which are published in this and other journals is contained in the report of the Meteorological Committee of the Royal Society, issued with the Parlimentary papers yesterday. This committee is entrusted with an annual grant of £10,000 to cover the cost of the observations conducted under its direction. General Sir E. Sabine, R.A., K.C.B., is the chairman, and the services

of all the members, ten in number, are gratuitous. The office receives, or would receive, were the continental telegraphic communications and that with the Shetlands perfect, fifty-one reports every morning, and nine every afternoon, except on Sundays. The observations are taken on Sundays as on other days, but are not received at the Meteorological Office until Monday morning, when the report for Sunday is made out. The stations are situated along the entire coast of the Continent, from Christiansund, in lat. 63 deg. N., to Corunna, in lat. 43 deg., with four stations on the coast of the Baltic, and one at Cape Sicié in the Mediterranean. The system is unfortunately most defective along our own western coasts, owing to the imperfections of telegraphic communication in those thinly-peopled and mountainous districts. The only stations along the line in question are Valentia, Greencastle on Lough Foyle, Ardrossan, and Stornoway. The committee are not without hopes that they may be able to carry out the idea, proposed in their last report, of establishing a station at Mullaghmore, a low-lying point on the south side of Donegal Bay, not far from Sligo. The possibility of deriving benefit, as regards the probable weather of these islands, from constant reports from America, has frequently been inserted in the newspapers and in scientific journals, but the experience of the office, which for four years received daily reports free of charge from Heart's Content by the liberality of the Anglo-American Telegraph Company, is not favourable to the idea of incurring expense for such a service. Not only was little benefit derived from such isolated and unsupported reports, but the subsequent study of the weather recorded in ships' logs has shown that atmospheric disturbances, though they may cross the Atlantic occasionally from shore to shore, in most instances undergo such changes in their progress that the fact of the severity of a storm on the coast of America is no gauge of its probable character when it arrives on our shores. The daily observations are taken at 8 a.m., Greenwich time, and most of the telegrams arrive in London about nine o'clock, when the Intelligence Department of the Post Office extracts from them the portions required for its wind and weather reports. They are then at once transmitted to the office by the private wire. About two hours are required for their reduction, discussion, and the preparation of the daily weather report, copies of which are ready about 11 a.m., and are at once supplied for the afternoon issue of several of the London papers. A wind chart for the day is also drawn for the *Shipping Gazette*. A brief telegraphic resumé of the weather is despatched to the Marine Ministry in Paris, and, if necessary, telegraphic intelligence of storms or of atmospherical disturbance is sent to our own coasts and to foreign countries. Later in the day the foreign telegrams, and subsequently the afternoon reports, come in. The daily weather charts are drawn by noon, and forwarded to the lithographers to be printed. The copies for postal distribution are received at the office at about 3.30 p.m. The total number of copies issued every day is about 530.—*Daily News*.

Notice to Correspondents.

Mr. Fahie's solution of Mr. Edison's problem is quite correct. We have not seen Mr. Edison's own solution.

HOW IT FEELS TO BE STRUCK BY LIGHTNING.

Mr. A. Castle, a farmer in Whitewater, Mich., was recently struck by lightning, and thus describes his sensations:—As the storm came up, he says, he put his team in the barn, and sat down in the door facing the inside. A stroke of lightning which killed his horses and prostrated him did its work too swiftly to give him the slightest warning of its coming. His first remembrance, upon returning to consciousness, was hearing his daughter, who had run down from the house, about 25 rods distant, exclaim, "Oh! father is dead!" Upon opening his eyes, the whole air and sky seemed to be ablaze. He says the pain was like that of a burn, and that he could not have suffered more for the hour that followed if he had been held in the flames. His wife and daughter, upon seeing that he was still alive, desired to remove him to the house, but he begged to be left where he was and not to be disturbed, as he felt that he could live but a few minutes, and that he might as well die there as to be put to the needless torture of removal. As he seemed to gain strength, however, he was taken to the house and made as comfortable as possible, but eight or ten hours elapsed before he was able to move either of his lower limbs. The left hip and leg seemed to be more affected than the right, and the symptoms for a time indicated that the bones were injured. But these have passed away, and a slight lameness now remains. The right lung has been very sore since the occurrence, but this may have been caused by an injury received in falling. The mark of the lightning is apparent from the shoulders to the calf of the right leg, in the shape of a broad, irregular strip, from which the skin has peeled off as though it had been scalded.

A new telegram code has been compiled by Mr. George Ager, LL.D. (published by Williams and Co., Moorgate-street) for the use of bankers, merchants and shipowners. The code is written in accordance with the St. Petersburg Telegraph Convention, each code word not exceeding eight letters, and is intended for use privately as well as publicly, also providing a method for insuring the correctness of a message.

To Correspondents.

*** Duly authenticated contributions, theoretical and practical, on every subject identified with the interests of which "The Telegraphic Journal" is the organ, will always command attention. Anonymous correspondence will be wholly disregarded. Literary communications and books for review should be addressed to the Editor; business communications to the Publishers, 10, Paternoster Row, E.C.

THE TELEGRAPHIC JOURNAL.

Vol. III.—No. 66.

SIR CHARLES WHEATSTONE.

Sir Charles Wheatstone died in Paris on the 19th ult., of congestion of the lungs, aged 73. No more prolific and untiring mass of human ingenuity has lived during the present century than Charles Wheatstone. He was in harness till the very last. He was visiting Paris to watch the inauguration of his latest feat in telegraphy—the automatic system—between that city and Marseilles, when he was seized with his fatal illness. His loss will be severely felt, and his well-known figure missed from many a pleasant scientific gathering. There is scarcely a branch of physics that has not been graced by some pretty experiment and illustrated by some ingenious apparatus of his; but it is in the field of electricity where his fame will chiefly rest. His share with Sir William Cooke in introducing the needle system, his A B C apparatus, his automatic system, and his clocks will leave a name behind which will always place him in the very front rank of the useful benefactors of this ingenious age. Our readers will profoundly regret his loss. He was buried in Kensal Green Cemetery on the 27th ult., surrounded by a large gathering of his scientific compatriots and brothers in arms.

NEW ZEALAND TELEGRAPHY.

This growing, enterprising colony has again put forward a satisfactory and prosperous report of its telegraphic operations during the year ending June 30th, 1875. The revenue was estimated at £55,000, but it has exceeded that amount by over £800. During the year 917,128 telegrams of all codes were transmitted, being an increase of 164,299, or more than 17 per cent. over the previous year. There is a balance of £9,460 13s. 4d. as interest upon the capital expended.

The number of telegrams transmitted during the year (917,128), compared with the number of inter-provincial letters posted during the year, shows that 22·59 telegrams were sent for every 100 letters posted. The proportion is not quite so great as last year, but the fact that there is nearly one million increase in the number of letters posted as compared with the number of letters for the previous year will account for it.

To enable masters of vessels to ascertain the state of the weather prevailing at any port to which they might be bound, or at any intermediate port, the system of sixpenny telegrams, including reply, has been introduced. The facilities thus afforded, when generally known, will doubtless be taken great advantage of by maritime men.

A like facility for obtaining news at a reduced rate was also granted to all Chambers of Commerce throughout the colony, who might be desirous of acquiring for public information the arrivals and departures of shipping at the various ports. The consideration in this case asked for by the department was, that telegrams containing shipping intelligence, the same being positively for public and not private information, be paid for at the rate of 3d. per telegram for each vessel. This concession has not as yet been taken great advantage of, but will doubtless, with the general progress of the colony, be adopted to a considerable extent.

During the past year 456 miles of new lines, carrying a single wire have been erected, and 988 miles of wire have been added to the original lines, making a total addition of 1,144 miles of wire. There are now opened to the public throughout the colony 127 stations, 21 of which have been opened during the past year, 6 being in the South Island and 15 in the North Island. The length of line maintained during the past year was 2,955 miles, the average cost for maintenance being £4 16s. 4d. per mile. At the close of the year 2,986 miles of line, carrying 6,626 miles of wire, were in circuit, showing an increased mileage upon the previous year, of line 456 and of wire 1,444. The nominal strength of the department, including linemen and inspectors, on the 30th June, 1875, was 509, against 388 of the previous year.

The duplex system of telegraphy has been in successful operation on the No. 3 wire in the Cook Strait Cable since the 18th of June, 1874, and the advantage of speedy communication consequent thereupon has been very obvious. Instruments are now ready, and the system will be immediately introduced on the No. 3 wire north to Napier, and on the No. 3 wire between Blenheim and Christchurch. With the additional wires erected between Napier and Wellington, it is anticipated that this will greatly facilitate the transmission of the increasing work now offering.

It is proposed to introduce shortly the Automatic system on some of the longer circuits, instruments for this purpose having just arrived from England. In the transmission of long press messages, which may possibly require to be sent in various directions, the saving of labour cannot be over-estimated. It is proposed to lay a second single wire cable across Cook Strait, so as to have an alternative line in the event of the existing cable breaking down.

ON A SYSTEM OF TELEGRAPHY.

A Course of Lectures, delivered at the School of Military Engineering, Chatham,

By W. H. PREECE, Member Inst. C.E., &c.

Lecture II.—A System of Telegraphy as applied to Commercial Purposes.

(Continued from page 233.)

As an illustration of what can be done by its means (the automatic system) I will take Mr. Bright's speech delivered at Birmingham recently. Twelve Wheatstone circuits in the place of the one usually at work were fitted up at Birmingham, communicating direct with 32 different towns grouped in this way—

Birmingham. Darlington. Newcastle.
Edinburgh. Dundee.

160,000 words, equal to 80 columns of the *Times*, were actually transmitted over the wires, and 500,000 words were actually delivered, printed, and published. The transmission of the speech commenced within ten minutes of Mr. Bright's rising to address the meeting, and finished to all stations by 2 a.m. Only one strip was punched, which passed through each transmitter successively.

Although a wire worked with the Morse apparatus has transmitted on an abnormal occasion, with specially skilled operators, 82 messages per hour, and it *could* maintain this speed, the average over the system is not more than from 30 to 35 messages per hour. The Automatic, on the contrary, could transmit experimentally 300 messages per hour. The rate of working, however, varies very much with the distance between the stations. It is quite possible, on short lines, to send at the rate of 200 messages per hour, or even more, but when we use long wires, suspended in the air, buried in the earth, or submerged in the sea, electrical embarrassments due to induction are introduced, which materially diminish the speed of transmission. Between London and Manchester as many as 174 messages have been sent in the hour, but the average rate of working is 120; between London and Sunderland it is 90; between London and Aberdeen 60; and between London and Dublin 55. Generally it may be said that the Automatic apparatus has doubled the capacity of all our long wires, and quadrupled that of our shorter ones, and there is no doubt that it is capable of much further improvement and development.

All the messages have to be prepared by manual labour, and punching cannot be done at a greater rate than 45 words per minute. Hence delay occurs in preparation, and errors in punching, and this to some extent limits the utility of fast apparatus for ordinary short public messages. For "news" it is, however, invaluable.

It is also invaluable when a sudden glut of work is handed in, or when the ordinary communication is interrupted through storms and accidents; but it cannot be employed as a rule economically under distances of less than 200 miles, for within that distance it is cheaper to erect extra wires to improve the circuit capacity.

On long lines a limit is reached where the rapidity of hand manipulation equals that of mechanical manipulation; but automatic work still maintains its clearness, accuracy, and regularity. Great efforts are now being made to improve the rate of receiving, and some astonishing experiments have been made between London and Liverpool, though nothing practical has yet been gained.

The A B C is the simplest of all forms externally. It consists of a dial, upon which the letters of the alphabet are placed, and before which a pointer, propelled by currents, is rotated, stopping at the letter which is required to be indicated. Words are spelt directly, letter by letter. Any person who can read and write can send and receive messages by it. The earlier forms were crude and rough, but the teachings of experience have led to great refinements in workmanship and beauty of mechanism: and, as a finished piece of apparatus, there are few instruments to surpass Wheatstone's A B C.

Its rate of working is slow. Very expert manipulators attain twenty words—but the average does not exceed four or five words per minute.

It is very delicately constructed, and very liable to get out of adjustment; but it has the great advantage that it is worked without batteries; and it is supplied with an alarm, which is most useful in attracting attention in offices where messages are few and far between.

The Hughes printer records its messages in bold Roman type, upon slips of paper, which are delivered to the receiver of the message. It is a very fast working apparatus, and has recorded as many as 54 words in the minute. It dispenses with writers, and, therefore, only employs one clerk at each end. Though very accurate, it is very costly, both in construction and maintenance; and it necessitates the employment of the most intelligent and experienced class of clerks at each end, as well as the convenience of a workshop to conduct repairs rapidly.

The Bell Telegraph is an acoustic instrument, which transmits its indications by transient audible signals, differing in tone. There are two bells of different notes: the one operated by currents in one direction, the other by currents in the opposite direction. The one signifies a *dot*, the other a *dash;* or the one corresponds with the movements to the left side of the single needle, and the other with the movements to the right side. It is very rapid in its working; 40 words per minute is a common speed. The receiving clerk writes his own message; his eye is confined to what he commits to paper—his mind is free to follow the sense of the message; and he is simply in the position of being addressed by a clerk—perhaps two hundred miles away—who dictates each word, not as it is spoken, but as it is spelt.

But the instrument is complex in its construction (it cannot be worked with double currents), and though there are many great advantages attached to it, its continuance has been doomed, and it must gradually and inevitably retire before its more fitting rival—the *Sounder*.

The Sounder transmits its indications by transient audible signals, differing in *duration*. It is, in fact, a Morse recorder, bereft of its clockwork and its paper. A sharp stroke, delivered on a species of sounding-board—equivalent to a crotchet in music—is a dot, and a prolonged sound—equivalent to a minim—a dash.

It is the simplest possible form of apparatus; it is light and portable; it contains no mechanism: it is simply an electro-magnet, with its armature and antagonistic spring; it is an alarm, and is as rapid as the Bell, and it can be read faster than any writer can write; it is more accurate than any other form of instrument dependent on transient signals, for it involves accurate and careful sending, and can only be manipulated by experienced and well-trained clerks. The ear guides the hand in manipulation, and the clerk trained to read by ear must necessarily become an accurate sender. It is for this reason that I contend that the proper plan to train a Morse clerk is to teach him first of all to read by sound only, and not allow him to attempt to send until he can read well. By teaching him to send first he acquires bad habits, which are frequently very difficult to unlearn.

The sounder instruments, being so simple, are easily kept in order, and they consequently very rarely fail. It is a very conversational form of instrument, and it thus enables errors to be rapidly corrected and repetitions instantly obtained. The ear is not so easily tired as the eye, hence it is a favourite with the staff. Moreover it does not try the eyes or injure the eyesight.

It has supplanted all other forms of instrument in America, but it has until recently been but little used for general work in Europe. It is being rapidly introduced by the Postal Telegraph Department.

The instruments found in use at the transfer were the A B C, the Needle, the Bell, the Morse, the Wheatstone (Automatic), and the Hughes printer. It was intended originally to employ the *single needle* upon all sub-office circuits, and the *Morse* upon all head office circuits, but Morse clerks were scarce, and their training occupied much time, hence single needles were necessarily employed at the head offices because the clerks existed, but they could not be found in sufficient numbers for the sub-offices, and the anticipated business would not pay for the employment of skilled labour. Thus the A B C forced itself upon the department. The Bell was necessarily retained, for an army of clerks trained in its use were transferred to the service. The automatic and Hughes were but sparingly in use, but the merits of the former have thrust it into very prominent employment, while the latter has made little or no headway.

The stations which were to be provided with apparatus were:—

The small village *sub-office*, where the ancient grocer and his wife, as a reward for some past political service, were allowed to dispense stamps and butter, issue money orders and cheese, sort letters and herrings, dispatch mails and soap. The counter was cleared of its lard, its scales, its parcels, and its stinks, and a portion parcelled off to receive the wonderful telegraph. Many timid villagers dreaded the trial, and resigned their appointments; others sickened under the prospect of its arrival. Some declined altogether to have anything whatever to do with it.

What business was anticipated? Possibly a message a week, may be a message a day. This at 1s. would not pay for a skilled clerk, and the 1d. per message perquisite did not open the road to fortune. The village government representative must either work the instrument himself, or his wife, or his maid.

To teach him the Morse was hopeless, to acquire the needle was equally so. There only remained the A B C, and this instrument seemed specially ordained for such a case. Hence small post-offices were worked with the A B C, and were it not for the engineering difficulties involved in its maintenance, no more fitting instrument could have been devised for such a purpose. But it is troublesome to keep in order when fixed on crowded circuits in spite of its beautiful mechanism and exquisite construction.

As the business of these small sub-offices increased, or as the population and dimensions of the village approached the importanoe of a town, the number of messages became sufficient to employ skilled labour, and too numerous to be despatched without delay upon the A B C circuit. Single needles were employed. The office is perhaps in some small linen-draper's establishment, where a side room is portioned off for postal and telegraph work. The young ladies of the house attend to the general business, one is apportioned to attend to the telegraph duties. She speedily masters the instrument, and the natural qualification of the sex renders her especially adapted to attend to the telegraph business of the office. There is scarcely any duty more adapted to the peculiarities of the female temperament than that of telegraphy. Her sedentary habits, her homely quiet ways, her patience, and her industry secure her unremitting attention, and nowhere are the telegraph duties more efficiently performed than in those small towns where the work is just sufficient to occupy her attention.

The opponents to the transfer of the telegraphs to the State sneered at the village postmasters and postmistresses, and pronounced them totally unfit to be employed as telegraphists. I am bound to say that I shared in the doubts as to their efficiency. The postal authorities themselves scarcely expected the sub-postmasters to be as attentive or as proficient as established clerks. Experience has refuted all these surmises. The work of the small offices is better done than it ever was in the railway and smaller offices of the Telegraph Companies, and though I do not pretend to say that the service is perfect, for we cannot expect experience and technical knowledge behind the small tradesmen's counters; I do say that it is better done now than it ever was before, and the amount of zeal, earnestness, and energy displayed for such small remuneration is a source of never-ending surprise.

Such offices ruled by sub-postmasters or sub-postmistresses are always subservient to some larger office, called the *head office*, presided over by a regular appointed postmaster. They cluster around these head offices in groups, and all the messages for such offices circulate through their head office.

Circuits are formed, embracing not more than three or four offices in the case A B C's, and five or six in the case of needle circuits.

The head offices in the smaller towns are generally in some tradesman's shop—the chemist or the bookseller—who screens off a portion of his space for the postal and telegraph work; but in all the larger towns where the business justifies it, special premises are devoted to this work, and a regular established postmaster appointed. At one office the postmaster keeps a regular *omnium gatherum*,

On one side is advertised "Post Office, Money Order Office, Savings Bank, Postal Telegraph," and on the other "Pickles, Cattle Medicine, Perfumery." The postmaster controls and supervises all the sub-offices under his charge.

The head offices are placed in direct communication with each other, and with the chief centres, such as Manchester and Birmingham, which again in their turn are connected with the chief telegraph station in London, known as T S, so that messages are sent from place to place by the most direct routes, and every office is provided as much as possible with alternate circuits or double outlets in cases of accident or pressure.

The system before the transfer of the telegraphs to the State was mainly directed to place London in communication with the Provinces, but the Post Office has placed all towns that have business relations in direct communication with each other, and has diverted as much as possible the circulation of messages through London. It has done all in its power to prevent the unnecessary repetition of messages, and to reduce the number of transmissions to the fewest possible, for every transmission means increased cost in working and extra liability of error.

All head offices as a rule are worked by Morse circuits; some few still remain worked by needle circuits, but gradually, as the business increases, the needles are being supplanted by the Morse and the Morse by the sounder. Where several offices remain on one circuit, the needle is retained, but intermediate working induces delay, and as soon as the business admits of it, direct wires, fitted with Morse instruments, are supplied. Head offices are almost invariably worked by trained telegraphists, either in the employment of the postmaster or directly in the service of the Crown. All the large transmitting centres are worked entirely by a trained and experienced staff, under the direct control of the postmaster of the town in which it is placed.

It may be taken as a rule that, when the messages are very few, A B C instruments are used. When the number of stations on a circuit exceeds four, or when the number of messages exceeds twenty per day, then single needles are fixed. As the business increases the single needles are replaced with Morses. When the number of messages exceeds fifty per day it is time to consider the necessity of a direct wire. One such wire can transmit without delay 150 messages per day. If the messages approach 200 a day, another wire is wanted. If the distance between the stations and the amount of business warrants the expense, then Wheatstone's automatic is fixed, and this can readily transmit from 400 to 500 messages per day.

Recently duplex telegraphy, which enables messages to be sent simultaneously in opposite directions on the same wire, has been introduced. It simply duplicates the capacity of all *direct* wires, and it has placed in the hands of the Postal Department, a most valuable and useful auxiliary apparatus. Indeed without it, and with the recent stoppage of all works, it would have been difficult to have transacted all the work of the Department during the very busy autumn which has just passed, without inconvenience or delay. It is applicable to all kinds of instruments.

It may be said generally that the teaching of experience is showing that the instrument of the future for ordinary commercial work is the "sounder."

(To be continued.)

A NEW SYSTEM OF ELECTRIC TELEGRAPHY.

By PAUL LA COUR,

Sub-Director of the Meteorological Institution of Copenhagen.

(*Presented to the Royal Danish Academy of Sciences at the Meeting of February* 12, 1875, *by Mr. Holten.*)

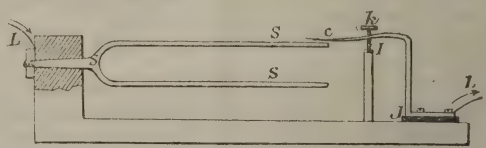
In the Electric Telegraph, up to the present time, but two simple signals have been employed, and these have been formed either by currents in opposite directions, or by the prolongation, to a greater or lesser extent, of the duration of the current. The system, which I devised on the 10th May last, enables, however, a large number of simple signals to be made with a single conducting wire.

When a vibrating body, at each of its vibrations, is made to close and open an electric circuit, the pulsations of the current will, of course, be isochronous with the vibrations of the sonorous body; and when such currents are, by means of electromagnets, made to act upon a second sonorous body vibrating in unison with the first, the second body will vibrate, whilst another similar body giving a different sound will remain silent.

The first experiment was successfully made on the 5th June, 1874, but it was feared that the vibrations might cease to be perceptible after traversing a long distance. I therefore made an experiment upon a telegraph line, 390 kilometres in length (from Copenhagen to Frederica and back), and even with a rather weak current, the pulsations were easily perceptible. This experiment was made during the night of the 14-15 November in the same year.

To produce the intermittent currents and receive them at the further end, the sonorous bodies employed were tuning-forks. The apparatus is constructed in the following manner:—

The key or instrument, which produces the intermittent currents in the line, is shown in the following figure:—



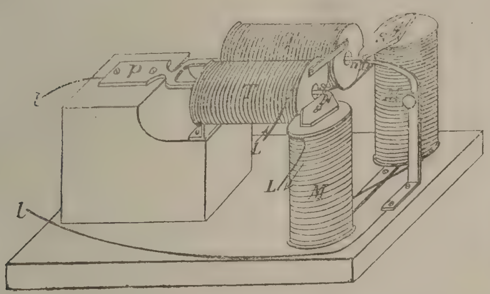
S S is a tuning-fork fixed by the shank in such a way that at each oscillation one of the prongs touches the contact *c* during a portion of the oscillation. The contact *c* can be adjusted by the screw *k*, and together with its support, is insulated from the tuning-fork by the insulating piece *J*.

When the shank of the tuning-fork is connected to one of the poles of a voltaic battery whose other pole is to earth, and when the contact piece is connected with the telegraph line and thence to earth, a blow given to one of the prongs of the fork will cause an intermittent current to be sent into the line, the pulsation of the current being in unison with those of the fork.

It follows that, by keeping the fork in vibration,

the same result will be obtained, whenever the circuit is closed at any given point. It always follows that, by employing a contact upon the inside of the fork with a special battery for the same, the line can be charged with a succession of currents in opposite directions.

The receiving apparatus is shewn in the next figure.



$n\ p\ s$ is a tuning-fork of soft iron giving the same sound as that of the key. The prongs are inserted lengthwise in the two coils $T'\ T$, which are surrounded by silk-covered copper wire; the prongs are so arranged as to vibrate freely within the centres of the coils. The intermittent current, on arriving at the station, passes through these two coils, and thence into the wire of an electro-magnet $M\ M$, which is arranged so that its poles are placed in front of the opposed poles produced in the fork. It is evident that the current, in magnetising the electro-magnet and the fork, produces an attraction which will open the prongs of the latter, but directly the current, and consequently the attraction, ceases to operate, the prongs will return to their position of equilibrium, and so on. If then the pulsations of the current are in unison with those of the fork, the vibrations of the latter will soon attain a sufficient extent for one of the prongs n to touch the contact piece D, closing the circuit $l\ l$ of a local battery, and thereby manifesting the arrival of the current in the usual way, either directly or by means of a relay.

I cannot as yet, I admit, state the time required to produce in the fork of the receiving apparatus vibratoins of a certain extent; it is a function of various factors; but experiment shows that the time which elapses before the local circuit is closed is so small a fraction of a second as to be hardly perceptible, even when the current is very weak. In the hope that this system will play an important part in electric telegraphy, I beg to here point out its principal advantage.

The intermittent current acts upon that tuning-fork only which is in union with the fork of the key. If then any number of different keys are arranged and the same number of receivers to correspond, an equal number of simple signals can be produced, each of which requires but a single movement. If each of these signals corresponds to a letter, figure, or other sign, messages may be sent more quickly than by present methods, and the receivers can be made to act upon a printing apparatus without any difficulty.

The same peculiarity will admit of the employment of these signals where several stations are connected together by a single cable. A signal can be sent between any two of the stations without the others being aware of it. The system might also become applicable in various other circumstances, for example: to call, give warning, announce the occurrence of an accident, fire, torpedoes, &c., in a word in all cases where it is desired to transmit signals only to certain points.

Another important property of the system is that *several signals can be produced* SIMULTANEOUSLY *upon the same wire.* For when several keys are acted upon at the same time, the current thus produced, with simultaneous intermissions of different duration, will only act upon the receivers corresponding to the vibrating keys, if only the forks have been selected in such a way as to avoid simple harmonies between them. Thus, for example: by employing a system of ten tuning forks, ten simple signals can be produced, then $\frac{10 \times 9}{1 \times 2} = 45$ signals when combined two and two, without the latter requiring more time than the simple signals. The question of the limit to the number of forks which can be vibrating at the same time is one that can only be determined by experiment.

The same property makes it possible to transmit several messages to various stations, employing but one wire. For example; station A is connected by a wire with station B, whence the wire is continued to station C. Station A can use two different systems of keys, one for station B and the other for station C. The receivers at the two stations must, of course, correspond with the keys. The same property also enables the system to be employed for pantelegraphs of a more reliable and quicker form than those made by Bain, Caselli, and others. Up to the present time only one style has been used in such telegraphs, and this style has to pass over the whole surface of the telegram to produce a copy of it; in the new system, however, as many styles as may be desired can be placed side by side in the form of a comb, which will then pass over the surface of the message in one direction only. By this method also, there is the advantage that an exactly equal speed is not required in the two instruments, for the only inconvenience which would result from a difference of speed between the original and the copy would be a slight contraction or extension in width of the whole message.

Lastly, the receivers have the valuable peculiarity of *letting ordinary electric currents pass through them without any indication of their presence*, at least, unless the currents are of very considerable intensity, so that atmospheric and terrestrial currents would not, as a rule, interfere with the working of telegraphs arranged upon this new system.

ON TELEGRAPH CONSTRUCTION.

By JOHN GAVEY.

(Continued from page 233.)

Line Insulators.

The two principal points for consideration in the selection of an insulator, are its form, and the material of which it is composed.

These have been varied in a multitude of ways, but certain definite principles can be laid down, which are of more or less universal application.

First, the electrical qualities require attention, the object being to obtain an insulator which op-

poses the greatest possible resistance to the passage of a current of electricity. Conductivity is possible either through the mass of an insulator or through a film of moisture or conducting material over its surface. To provide against the former, a material which as nearly as possible offers an infinite resistance should be selected. It should be homogenous, uniform in quality, and not porous, or in any way an absorbent of moisture. It should not deteriorate, crack, or split, by exposure to atmospheric influences, but should retain permanently the qualities sought for in its selection.

Surface conduction arises from the deposition of a film of moisture, or of the more or less conducting substances which float about in the atmosphere. The resistance of an insulator to loss from surface conduction depends primarily upon the form given to it, and in deciding this point, the ordinary law that the resistance of a conductor varies directly as the length, and inversely as the section, affords a guide as to the dimensions that should be adopted; any means by which the length of the insulator is increased and the diameter diminished increasing its resistance *per se*—the affinity for moisture, however, of the material employed, the smoothness and evenness of the surface, the readiness with which dirt adheres to it, and insects form their nests within the interior, and the facility with which the surface can be washed by rain, all tend to vary the results obtained with different forms and materials, and should all be carefully taken into account in considering the relative value of various forms employed by different services.

The materials used are varied, and the qualities to be sought for, in addition to those already specified, are sufficient tensile and compressive strength to withstand with success the greatest strain likely to be brought on them. They should be readily moulded or wrought into the desired shape, and should be tough and adapted to resist a certain amount of rough usage to which they will inevitably be subjected. Glass, stoneware, porcelain, ebonite, and wood impregnated with insulating compounds have all been used with various degrees of success. Glass was widely used in England in the early days of telegraphy, but the readiness with which moisture was deposited on its surface, and its liability to crack, caused it to be rapidly replaced by stoneware and porcelain, which are the two materials wholly used in this country. It is possible, however, that its use may be revived with great advantage if the electrical qualities of the toughened glass, of which so much has lately been heard, are at all comparable with its alleged mechanical ones.

Stoneware and porcelain, the former especially, are excellent materials for insulators. If selected with care, properly manipulated, thoroughly burnt and vitrified throughout their whole substance, they are proof against all ordinary vicissitudes except that of mechanical violence, to which unfortunately they are most subject. The materials are readily moulded into any desired form, and a clean, well glazed, thoroughly even surface is easily obtained. Ebonite, one of the most perfect of insulators as a mass, soon deteriorates over its surface, which becomes partly conducting through the adherence of dirt. Wood has been used as giving a substance which can withstand with impunity the stone-throwing proclivities of mischievous persons. The difficulty with this material, however, is to give it that thoroughly smooth surface which is of such importance to the continued efficiency of a line.

The earliest practical insulator that was used to any extent in this country simply consisted of a short cylinder of glazed earthenware, with a hole through its axis and a groove round its circumference. It was held to the pole by means of a small clip, fitting the groove, and the wire passed through the axial hole in the earthenware.

This was shortly afterwards modified, the cylinder being lengthened and the ends tapered in the form of a double cone. Later, with the object of diminishing the deposition of moisture on the earthenware, the latter was formed into a solid cylinder, perforated at one extremity at right angles to its axis for the passage of the wire, and covered at the upper end by a zinc cap, which surrounded the greater portion of it.

Although this achieved its object, the remedy was as bad as the disease, for the cap, without in itself impeding the escape of the current, fostered the accumulation of dirt and spiders' nests, so that the insulation left much to be desired.

This was followed by the umbrella-shaped insulator, known to old telegraphists as the "No. 3," which was a direct descendant of the last form, the zinc cap being replaced by an earthenware or glass one. This insulator did good service, but as the system extended, and longer lines became common, an improvement was found necessary. This was partly achieved by paying greater attention to the manufacture of the material, but the greatest advance was made in the form given to the insulator, which is a type of those now in use. This was introduced by Mr. Latimer Clark, who in 1856 patented his double cup insulator, which consisted of a double bell cemented on a bolt or stalk, by which it was attached to a bracket, the wire itself being supported by a suitable groove on the top of the insulator. Mr. Varley later improved on this by introducing an insulator in which a long narrow cylindrical cup was cemented inside of a larger one, so as to have a clear space between the two. A suitable bolt or stalk, to form an attachment to the pole, was fastened in the small cup, and the large one contained a circular groove near its upper end to retain the wire. By these means the mean section of the conducting surface was diminished, whilst the length was considerably increased. Further, by the use of two separate and independent cups, the additional advantage was secured, that a breakage or undetected defect in one of them simply reduced the effectiveness of the insulator, by say one half, instead of almost wholly neutralizing its insulating properties. For short lines single cup insulators, similar in outward form to the above two descriptions, are now used, but the former or modifications of the same principle are now employed on all important circuits in most countries.

Occasionally the insulators are protected against mechanical injury, by being covered with an outer iron cap. This, however, has a most injurious effect on the insulation, as it fosters the accumulation of conducting matter over the surface of the porcelain or earthenware, and impedes the beneficial action of rain, which in the ordinary type cleanses the exposed surfaces whenever it falls

heavily. To obviate this, perforated cups have been introduced, which, whilst protecting the brittle material from stones of a size to injure them, admit of the entrance of sufficient water during heavy rains to wash the insulators. Even these are, however, far inferior in insulating power to the ordinary unprotected form.

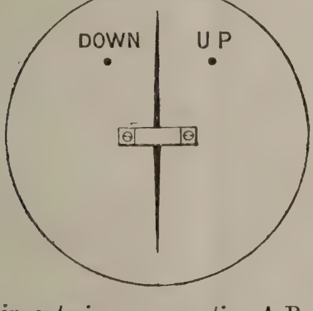
In testing insulators, they should be exposed to precisely the same influences as they will be subject to in actual practice, or fallacious results will be obtained. The minimum insulation resistance of an open line of telegraph in the worst weather, is generally taken at 200,000 ohms per mile. Thus, taking 30 insulators per mile as the maximum number which will be used at any time, a single one should not offer a less resistance than say 6 megohms after exposure for some months, and in wet and misty weather. Practically a higher result than this even should be given to counterbalance the effect of exceptional losses in the weak places which every long line exposes. Some years ago Mr. Culley, for the Electric and International Telegraph Company, inaugurated an exhaustive series of experiments on the value of various classes of insulators, which resulted in the adoption of the forms now in use in this country. Those who seek further details on the whole subject, are referred to his handbook, where it is treated of at length.

RAILWAY BLOCK SIGNALLING.

(Continued from page 218.)

To Mr., now Sir William Fothergill Cook, is the world indebted for the origin of the block system. In 1842 he produced a pamphlet, called "Telegraphic Railways," in which he suggested the principle of working which has been explained. His idea was to form the line into divisions of from 15 to 25 miles, and again to form these divisions into sub-divisions or sctions, of from 2 to 5 miles. Each station was to be provided with an instrument having upon its face as many indicators as there were sections or sub-divisions of the line, the indications made by the needle or pointer being two in number, viz., UP and DOWN (Fig. 2). On

Fig. 2.



an UP train entering—say section A B—B would, before allowing it to enter the section B C, set his indicator to "UP," at the same time ringing a bell at C. If the section was clear, C would pin over the handle of his indicator to "UP," and on the train passing B, B would release his indicator, which would indicate train had passed B. But one indicator would then be left open, viz., that belonging to C, and this indicating "UP," it would be seen by all stations in the division that an up train was running between B and C.

This system, although not complicated in its mode of working, was cumbersome and expensive. Judged by the present method of working block signals, it meant multiplying the number of instruments and wires at any one station by the number of sections composing the division; so that for a division of five sections, the cost would be something like twenty-five times that of the present system. It was, however, a great step in the right direction; and the railway world in particular, and the public at large in general, will ever remain indebted to Sir William F. Cook for the able manner in which he brought before the world that principle which is undoubtedly the only true and safe principle upon which railway traffic can be worked. Its first tral was on the Great Eastern Railway, between Norwich and Yarmouth, in 1844.

Further improvements were effected by Mr. Edwin Clark in his application of it on the London and North Western Line in 1854. Each set of rails had its own independent telegraph, by which the out-door signals were regulated. The instrument employed was that known as the "double needle."

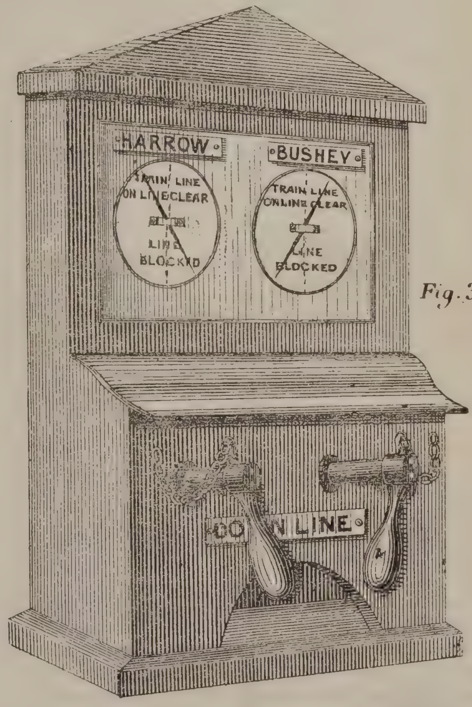


Fig. 3.

A deflection of the needle on one side, again indicating "line clear," and a deflection to the opposite side, "train on line," whilst the needle standing vertical indicated failure of instrument or the occurrence of an accident, and that the line was "blocked." The handles, by which the instrument was worked, were slotted in such a manner as to admit of their being pegged over either to one side or the other so as to give and maintain either of the indications named. Thus constant currents of electricity were always maintained on the wires either "for line clear" or "train on line."

At certain intervals the line wires were terminated on each side of the pole, and the circuit completed by a loop of small wire carried down the pole (fig. 4) so as to be within reach of the

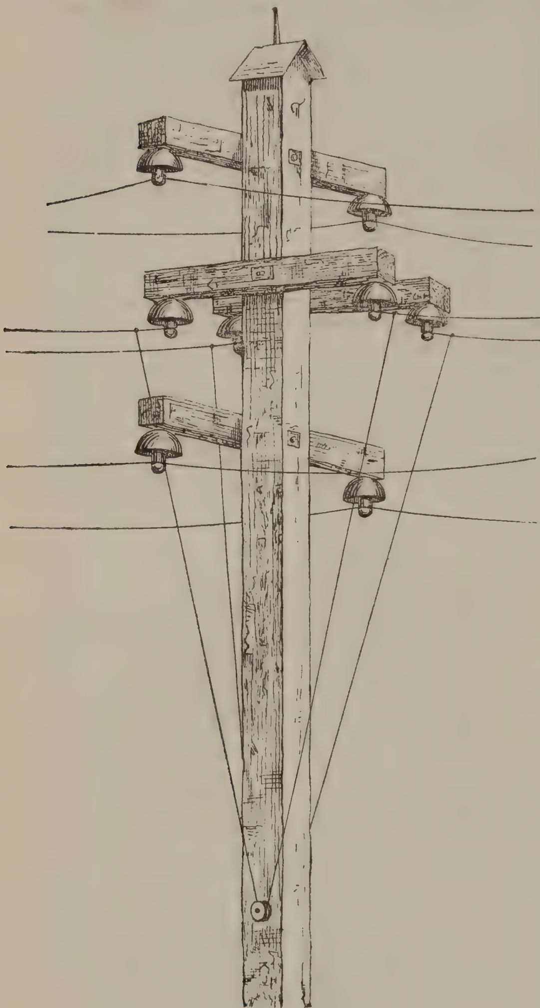


Fig. 4.

guard or any person standing on the permanent way. Should an accident arise, or it be necessary from any other cause to block the line, the cutting of these wires interrupted the circuit and produced the vertical signal indicating "line blocked." Though an ingenious contrivance it is questionable whether any advantage attended its adoption. From the fact that its use has not been extended, it may be inferred that if such was the case at the time of its introduction the necessity for it no longer exists. It is certain that in the confusion arising at the moment of an accident the chance of the wires being again joined by the guard—in accordance with the instructions—would be very slight. Not only do all such arrangements add greatly to the cost of construction, but they are a fruitful source of interruption, and at the best merely intimate, perhaps a moment or so earlier, that which the non-arrival of the train, or the absence of a signal to that effect would convey to the signal boxes at either end of the section. A question of still higher importance is moreover involved. The indication can be produced not only by the severance of the wire but by the failure of the battery; by the wire becoming in contact with other wires, or with the earth. A series of failures such as these would be likely to induce carelessness on the part of the signalman. He would conclude the failure was due to some defect with the apparatus rather than to an accident on the line, and become indifferent in his instructions to the engine-drivers of following trains to "proceed with caution." Anything which tends to reduce confidence in the signals in use, whether by its interference with their good and perfect working, or by inferences deduced from that or other causes, should be carefully avoided.

The Great Northern in adopting the telegraphic working upon that line of railway, although employing a similar form of instrument, applied to it a system inferior to that hitherto used. Both needles were used promiscuously for the up and down lines (fig. 5). "Train in" being indicated

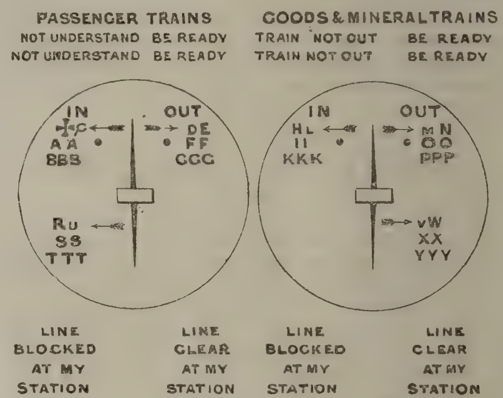


Fig. 5.

by one beat of either needle to the left, "train out" by the opposite motion; the signals "line blocked" and "line clear" being rendered by holding both needles over momentarily in the direction of those words. All signals were thus transitory or momentary, every signal being recorded in a book kept for that purpose.

The signals obtained by one and all of these instruments were produced by the same means, viz., a small permanent magnet fixed upon a spindle, to the extreme end of which was also fixed another needle, not magnetic, the spindle being so fixed as to admit of the magnet oscillating within a pair of coils. On the inner magnet or needle being influenced by the electric current, the outer needle repeated the movement, and thus conveyed to the signalman the indication required. Of more recent date is the induced magnet. The form described is objectionable from its liability to *demagnetization* or *reversal* of the magnetism of the inner needle by lightning. The employment of needles, the magnetism of which is induced by other magnets placed in their neighbourhood, is preferable; for although a false signal, as "line clear" when the line is *blocked*, may be, in this, as in some other instruments, produced by atmospheric electricity, it yet gets rid of the absolute *reversal* and *demagnetization* to which the old form of needle is subject.

MILL LIGHTING BY ELECTRICITY.

By A. TOLHAUSEN.

In spite of the many improvements which have been brought to bear on the various magneto electrical machines for the generation of light, the use of electricity for lighting up mills or other workshops in place of common oil or gas, has scarcely been introduced.

The "Journal für Gasbeleuchtung," however, recently observes that in the establishment of Messrs. Heilmann, Ducommun, and Steinlein, in Mühlhausen, electricity has been applied apparently with success for lighting-up purposes. In a separate room four magneto-electrical machines are placed, which feed other four suitably located lamps constructed on the Serrin principle. The dimensions of the room lighted up are 60 metres (196.8 ft.) by 30 metres (98.4 ft). Each lamp throws off a light equal to about a hundred Carcel lamps, and these are surrounded respectively by a glass globe which serves to blend the light intensity. The cost of the four lamps, excluding the maintenance of the motive power, averages about tenpence per hour.

During the three months which this electrical light has been working, no inconvenience has been experienced, the light given off being beautiful and steady, and uncomparable to any other mode of illumination. The magneto-electrical machines have each cost 1,500 frcs., or sixty pounds sterling, the whole arrangement amounting to 8,000 frcs. or £320.

With regard to the comparative cost of this electric light, with other means of illumination, M. Laboulaye furnishes the following table:—

	Quantity of material required for producing light = 1 stearine candle.	Cost of a light-intensity = to that of 700 stearine candles per hour.
Electrical light obtained by a magneto-electrical apparatus	.. ..	1s. 2d.
Ditto galvanic pile ..	.. ..	2s. 6d. 4s. 2d.
Coal gas	0.53 cub. ft.	2s. 8d.
Oil (vegetable) ..	79.92 grains.	5s. 1d.
Tallow candle.. ..	162.02 ,,	10s. 6d.
Stearine	160.47 ,,	21s. 10d.
Wax	127.45 ,,	27s.

In the preceding table the following prices have been assumed: gas, per cubic meter = 3d.; tallow, 17d. per kilogramme; stearine candles, 3s. per kilogramme; wax candles, 4s. 2d. per kilogramme.

To distribute the effect of the electric light in various directions and points in a uniform manner, the attempt has been made to pass the current through the different apparatuses by means of current deflectors, which break the currents passing through the lamps during so short a period, as to make the light appear to all intents and purposes as being continuous. The fact has been hereby utilised, that the impression made by light upon our visual organ remains intact during at least one-tenth of a second's duration. Moreover, the luminar arc between the carbon points becomes momentarily reproduced, provided the current interruptions are only of minute duration, a fact which has been repeatedly proved by the illuminating apparatuses of Siemens and Halske, as of late improved by Häfener Alteneck. Leroux has himself determined by experiments that the luminous arc between the carbon points becomes instantaneously reproduced provided the interruption of the current does not exceed one-twentieth of a second. This last-mentioned authority also succeeded in dividing the electrical light, by employing a rapid turning deflector, by means of which he alternately conducted the current of a Bunsen's battery to two lamps, in such a manner that each of these received an equal amount of currents in equal times; the luminosity given out by these was also equal in both lamps.

On the other hand, it would appear that this *modus operandi* is neither cheap nor practical, and it has therefore been further attempted to divide the electric light without having recourse to the luminous arc. The results, however, have not been satisfactory, inasmuch as the cost of such illuminations rank almost equal to those of gas or petroleum - lighting. These futile attempts induced Gramme to construct smaller machines with an equivalent light intensity of fifty Carcel lamps. These small lamps work very well alone; the light emitted is not perfectly steady; the best of the machines yet introduced, present a light of at least one hundred carcel lamps, with an average cost price of £60.

Although the foregone description does not solve the problem concerning the divisability of the electric light, it is possible that the modern improvements made in this direction, coupled with the reduced cost, may at no distant period lead to the lighting up of our mills, railway stations, &c., by means of electricity.

Correspondence.

TO FIND THE INTERNAL RESISTANCE OF A BATTERY AND ITS ELECTROMOTIVE FORCE AT THE SAME TIME.

To the Editor of the TELEGRAPHIC JOURNAL.

SIR,—The following expeditious method of finding the internal resistance of a battery and its electromotive force at the same time was devised by me last November. I now send it to you for publication in the hope that it will be as useful to many of your (practical) readers as it has been to myself. After several months' experience, I can recommend it as extremely accurate. It assumes nothing as known, as is the practice in most other methods.

A B Fig 1, is a set of resistance coils, most conveniently that arrangement known as "Thomson's Slide." C is any resistance, but if possible it will be preferable to make it approximately equal to R, the internal resistance.

Having connected the apparatus, as shown in the figure, the resistance A B is varied until the galvanometer shows no deflection. When this is so, the potential at the point P is equal to that of the standard cell or battery *e* (*vide* page 18 Clark's "Electrical Measurement;")

$$\text{therefore} \quad \frac{(A+B)\,E}{A+B+C+R} = e \qquad (1)$$

Now depress the key K, and, if the galvanometer needle be deflected, slide the travelling peg, to which the fron contact is attached, to or from the point P until the needle returns to zero. Let this be the case when the peg is situated as shown above. Then since balance is

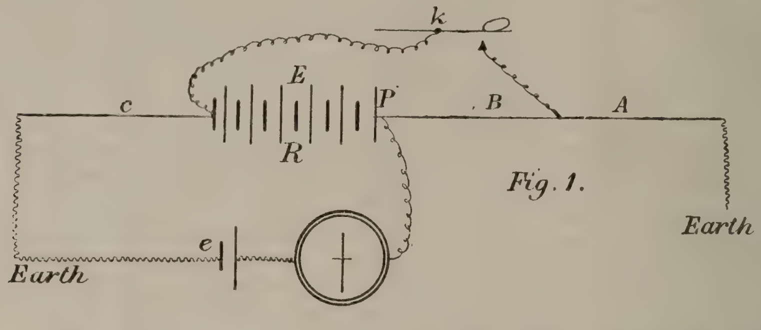


Fig. 1.

undisturbed the potential at P must still be equal to to that of the standard cell;

$$\text{therefore} \quad \frac{B\,E}{B + R} = e \qquad (2)$$

Combining equations 1 and 2, we get

$$\frac{(A + B)\,E}{A + B + C + R} = \frac{B\,E}{B + R} \qquad (3)$$

whence we obtain the formula

$$R \;..\; C\frac{B}{A} \qquad (4)$$

or in another form $A : B :: C : R$.

Now knowing the valves of A, B, C, and $R\ (= C\frac{B}{A})$ and knowing also that the potential at $P = e$, we can find the electromotive force E by the rule of similar triangles given at page 20 of Clark's work above mentioned—thus

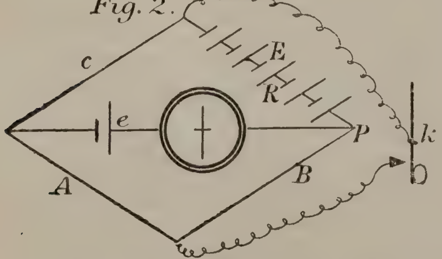
$$E : e :: A + B + C + C\frac{B}{A} : A + B$$

or simply $\quad E : e :: B + C\frac{B}{A} : B$, therefore

$$E = \left(1 + \frac{C}{A}\right)e \qquad (5)$$

Practically, and as an aid to the memory, Fig. 1 may be drawn thus.

Fig. 2.



I need hardly remind your practical readers that, in order to avoid polarisation of one battery by the other, the connection of the galvanometer with the larger battery and the depression of the key K should be momentary *until* balance of the needle is obtained in each case.

I may, however, mention that the internal resistance of a battery whose positive plates are "dirty" (as will be the case more or less with all batteries which have been at work some time) is very variable. True, this variation is generally very small, but it must not be neglected, for, since it makes R a variable quantity which *may* alter during the later portion of the test, E must also be variable to a propotionate extent. When therefore great accuracy is aimed at in determining the electromotive force of a battery, care should be taken that the positive plates are clean, and that their immediate surroundings contain no metallic substance in solution, or otherwise foreign to the plates themselves.

Shiraz, Persia, J. J. Fahie.
July 5th, 1875.

To the Editor of the Telegraphic Journal.

Dear Sir,—In No. 59 of your Journal, July 15th, 1875, I find a system of Quadruplex Telegraphy described by Mr. Kempe, which is a modification of that invented by Stark of Vienna. Now I have tried every one of the so-called devices for the transmission of two messages in the same direction at the same time, described by Düb, Schellen, Blavier, and others, including also Mr. Kempe's, and will say that not one of these will allow of the transmission of a single word, and a very small amount of experimenting will make this evident.

It seems to me to be a real shame that such theoretical devices are put in standard telegraph works to be brought out against future inventors as an evidence of priority.

Respectfully yours,
Charles Batchelor.

16, Ward Street, Newark, N.J., U.S.A.
August 20th, 1875.

Notice to Correspondents.

We have received an angry letter from Calcutta respecting some remarks made in our impression of August 15th, in reviewing the Journal of the Society of Telegraph Engineers. As our correspondent simply questions the judgment of our reviewer, we regret we cannot publish his letter.

F. W. Young.—The sound made by the wires is due entirely to the moving air. It has nothing whatever to do with currents. Currents do not produce sounds in wires.

W. Tyrrel.—The book is now in the press, and may be expected very shortly. Mr. Kempe's papers, with corrections and considerable additions, are about to be published by Spon and Co.

Notes.

The *Hibernia*, with the second portion of the New Zealand cable, will leave in the early part of November.

The cable between Santos and Santa Catarina having been repaired, direct telegraphic communication with La Plata is now restored.

The Government of Western Australia propose to expend £28,500 in the construction of a line of telegraph to South Australia. The line will extend from Albany to Eucla.

We are happy to announce that Mr. F. C. Webb, C.E., who has lately returned successful from cable operations on the Brazilian Coast, has had conferred on him by the Emperor of Brazil the honour of a Knight Officer of the Order of the Rose.

Magnets prepared by compressing iron filings in tubes have been exhibited to the French Academy by M. Jamin. When soft iron filings are forcibly compressed by hydraulic pressure, they acquire a coercive power equal to that of steel.

It is semi-officially announced that the sub-committee of the Western Union Telegraph and the Atlantic and Pacific Telegraph Companies have agreed on a plan for a consolidation of interests, and that it is to be submitted to the respective board of directors.

The Indo-European Telegraph Company state that the average time in transit between London and India, *via* Teheran, of all outward messages to India, including messages for Penang, Singapore, China, Japan, Java, and Australia, during the week ending 22nd October, was 51 minutes.

The New South Wales Government have successfully adopted the Wheatstone Automatic System. Mr. C. E. Winter has just returned from Sydney, where he has been engaged in starting the system and instructing the staff. He brought away with him the warmest congratulation of the Postmaster-General.

The liquidator of the Panama and South Pacific Telegraph Company, Limited, announces that all the moneys owing to the company having been collected, he is enabled to declare a further return of 15s. 9d. per share to those shareholders who have paid up £2 10s. per share, and a return of 7s. 2d. per share to those who have paid only £1 per share, being the proportion due to them after deducting interest at the rate of 5 per cent. on the allotment money due the 31st January, 1870, not paid by them.

A curious statistical table has been drawn up in France showing the distribution of letters and telegrams per head in different countries. Switzerland is first in both classes, the telegrams averaging eight for every 100 inhabitants; in France there are 23 letters to every 100 inhabitants; in England 20 1-12th, and in the United States 19. In England there are 54 telegrams for every 100 inhabitants; in Holland 51; in Belgium 47; in the United States 32; in Germany 31. France ranks tenth, and Russia last with one.

The harmonic-electric telegraph invention (now commonly known as the telephone) of Mr. Elisha Gray, of Cleveland, is undoubtedly destined to prove a very useful and important one. On Friday of last week we saw four despatches transmitted simultaneously from Boston to this city, on one of the Western Union wires. It is believed, and with good reason, that at least sixteen messages can by this invention be transmitted simultaneously over a single wire. Mr. Gray has made a discovery and invention which will be likely eventually to revolutionise the present Morse telegraph system. (*The Telegrapher*).

Superintendent C. G. Merriweather, of the fourth district in the Southern division of the Western Union Telegraph Company, reports that the experience of the past season has proved conclusively that the application of lightning rods to telegraph poles is a matter whose importance should lead it to receive careful attention. On many routes under his charge, where a large number of poles were formerly destroyed by lightning every year, a dozen or more being sometimes shattered in a single day, the attachment of lightning rods has resulted most favourably, not a single pole having been damaged during the present season. He also states that no trouble has been experienced from accidental contact between the lightning rods and the line wires, although serious apprehensions were entertained that this would prove an obstacle to their successful use. The rods were placed on every tenth pole, and also on the nearest pole on each side of every office. (*Journal of the Telegraph*).

ON THE ACTION OF MAGNETS ON RAREFIED GASES IN CAPILLARY TUBES RENDERED LUMINOUS BY AN INDUCED CURRENT.

By J. CHAUTARD.

The spectral modifications produced by the action of magnets on the light of an induced current traversing rarefied gases are subject to very complex laws; and it is only possible to formulate them after varied and long-continued experiments. M. Trève, in a Note published in the *Comptes Rendus* (January 3, 1870), after indicating some facts bearing on this class of phenomena, concluded in these terms—"coloration and decoloration of the gases under the action of magnetism, in the capillary parts of the tubes containing them;" but the experi-

ments of the accomplished officer were not very numerous, they were made on only a few gases, and appeared to be only indirectly connected with the researches he had undertaken. The subject seemed to me sufficiently interesting to be the object of a fresh study, of which I have to-day the honour to present to the Academy a rapid summary.

Conditions of the Experiments.—Without returning to the experimental arrangements indicated in my first Note*, I shall briefly analyze those which have permitted me to extend, and at the same time give a precise account of, my fresh experiments. These are:—the nature, temperature, and pressure of the gas; the intensity, direction, and source of the induced current; the action of the magnet through the form of its poles, the energy and direction of the magnetization, the distance of the armatures, and the axial or equatorial position of the tube containing the gas †.

(1) The rarefied gases or substances on which my experiments have been made are hydrogen, nitrogen, oxygen, carbonic acid, carbonic oxide, bicarburetted hydrogen, sulphur, selenium, iodine, bromine, chlorine, sulphurous acid, fluoride of silicium, bichloride of tin. All of them are far from presenting very pronounced modifications, as I shall presently show; the substances of the chlorine group are those most sure to succeed, and produce the most brilliant results.

(2) Elevation of temperature lessens the effect produced by the magnet. This can be ascertained by causing the induced current to pass for some time within the tube: the heat resulting soon weakens and sometimes renders inactive the magnetic influence.

(3) The pressure of the gas interferes with the action of the magnet to such a degree that it is possible with the same substance to obtain, according to the conditions, either the sudden cessation of the induced current, or a notable modification in the luminous appearance, or the permanence of the initial tint.

(4) By varying the intensity of the induced current, effects can be obtained similar to those which result from varying the pressure of the gas: in general, the more feeble the initial intensity, the more decided are the magnetic luminous modifications.

(5) The phenomena are the same when the induced current is derived from a Holtz machine or a Ruhmkorff induction-coil.

(6) Both directions of the induced current, as also of the magnetization, give pretty nearly identical effects; certain substances, however, seem to undergo a more energetic influence at the moment of the reversal of the current.

(7) In the form of the armatures, the surface ought chiefly to be considered; this should be plane, and such that the capillary tube will be embraced over the greater part of its length.

(8) It is evident that the more energetic the magnetization, the more pronounced will the phenomena be; it is usually determined with the aid of a pile of 12-15 Bunsen elements (large pattern).

(9) Lastly, the action diminishes rapidly with distance; this is ascertained by gradually removing the tube to about ½ centim. from the poles; beyond that limit the influence of the magnet ceases to be manifest.

Conclusions.—(1) The first result to be noted is an increase of resistance of the part of the induced current under the influence of the magnet. This resistance is sometimes such that the current may be suddenly interrupted at the instant when the magnet begins to act. This is made evident in the following manner. A tube is taken formed of two parts in communication, one of them presenting a constriction, the other a different length and diameter. The capillary part is placed in the pole of the electromagnet, after which the current of the coil is started. As long as the magnet is inactive, the light circulates uniformly in the two tubes; it is suddenly arrested in the shortest and narrowest at the instant when this is submitted to the action of the magnet. The effect can be produced with chlorine, iodine, sulphur, selenium.

(2) This cessation of the induced light caused by the magnet can be determined, with the same gas, in two quite distinct cases—either when exhaustion has been carried so far that the induction-current is near the limit which no longer permits it to pass, or, on the contrary, when the tension of the gas is sufficient for the spark to be near the same limit.

(3) Under the magnetic influence the luminous thread, when it persists, undergoes in capillary tubes a narrowing which can sometimes be perceived by simple inspection. This narrowing is produced by an augmentation of resistance, sufficiently energetic at times to be accompanied by a change of tint in the tube, or even by a modification of the spectrum. In certain gases, such as hydrogen, nitrogen, carbonic acid, the influence of the magnet is hardly perceptible, and the modifications observed enter into the system of the primitive lines.

(4) This narrowing, or the change of tint of the luminous thread, does not extend to more than half a centimètre from the poles: thus on taking a tube of sufficient length, by changing the height of the spectroscope while the magnetization is going on, the normal spectrum (that produced by the light outside of the magnetic field) and the spectrum modified by the vicinity of the magnet can be successively seen.

(5) In order to form a good judgment of the action of the magnet, it is necessary to manage so that the spectrum is not very bright at starting. As soon as the current passes in the electro-magnet, the lines appear in all their splendour. The phenomenon is particularly successful, and gives the most perspicuous results with chlorine, bromine, chloride of tin, fluoride of silicium, and sulphuric acid.

(6) Direct measurements have proved that, for these last substances, the new lines developed under these circumstances are distinct from those which characterize the normal spectrum of the same gas traversed by a sufficiently energetic induced current outside the range of a magnet.—*Comptes Rendus de l'Acad. des Sciences*, vol. lxxx. pp. 1161-1164.

* *Comptes Rendus*, Nov. 16, 1874, p. 1123.

† The form of my apparatus has not, up to the present time, enabled me to compare the effects resulting from these two positions.

Improvements in Private Telegraphy.—Mr. R. S. Symington, of Glasgow, has just added another to the various novel and useful adaptations of the systems observable in various parts of the above city. Inside the lobby of the Royal Exchange has been erected a small office or enclosure labelled "Members' Private Telegraph Inquiry Office," inside which Wheatstone's alphabetical telegraphic instruments have been set down, having in connection with each switch, by which the current may be directed to any one of the twenty-five different wires. This switch may be described as an ebonite stand of circular form, having round the outer rim a series of twenty-five brass terminals to the wires, and an inner series of knobs of indicators. In the centre of this inner series is a handle, by turning which the current is directed to the particular wire through which the clerk in attendance is desired to convey a message. These wires are connected with the offices of all the members, and by this means the various business firms are placed in communication with each other and with the Exchange. On the receipt of messages at the Exchange they are posted by the clerk in a conspicuous part of the room, and a bell is rung to inform members of the fact. The messages are placed within a large case, divided into numbered pockets with glass in front; and as each member knows his own pocket, a glance shows whether the message is intended for him.

THE TELEGRAPHIC JOURNAL.

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SIR CHARLES WHEATSTONE.

Charles Wheatstone was born in Gloucester, in the year 1802. He was the son of a tradesman. He was educated in a private school in that city. He commenced early to fight the battle of life by the manufacture of musical instruments, an occupation which encouraged his natural taste for science and mechanics. In 1823, he moved up to London, and established a business of his own. The natural scientific bent of his mind drove him to search deeply into the physical laws upon which the instruments he made were based, and in the same year that he removed from Gloucester, he published, in the *Philosophical Annals*, an account of some "New experiments on sound." In 1827 he published in the *Quarterly Journal of Science*, "Experiments on Audition," and a "Description of the Kaleidophone, or phonic Kaleidoscope, a new philosophical toy for the illustration of several interesting and amusing acoustical and optical phenomena." In 1828 he wrote on the resonance of columns of air, and in 1831 on the transmission of musical sounds through solid conductors. In the latter year he gave an experimental proof of Bernouilli's theory of wind instruments, and in 1833 he read a paper before the Royal Society on those peculiar figures called "Cladni's" made by sand on vibrating plates. In 1832 he read a remarkable paper on Dreaming and Somnambulism, and he never ceased throughout his long life in taking deep interest in mental illusions and psychological problems. In 1835 he sent a paper to the British Association "On the various attempts which have been made to imitate human speech by mechanical means," and he made a machine which imitated very successfully some of the simple elementary sounds of the human voice.

In 1834 he was appointed Professor of Natural Philosophy in King's College, and in the same year he made his celebrated and classical experiments on the velocity of an electric discharge and the duration of the sparks by the aid of revolving mirrors; and fiom this period his mind seems to have been devoted to telegraphy. No one who had ever studied electricity could have failed to have seen its special adaptability to the conveyance of intelligence to distant points; and from Lesarge, in 1774, to Schilling in 1832, a dozen or more telegraphs were "invented" and freely given to the world. No one can claim the "invention" of the telegraph. Neither Wheatstone, nor Cooke, nor Morse were the first to employ electricity for telegraphic purposes, nor the first to convey intelligence to a distant point by means of electricity. The controversy on this point has been an unfortunate one. Sir Francis Ronalds in 1823 wrote a book on the subject, and his prescience is wonderful to contemplate; but he only described in an improved form what Lomond had done in 1787. Cooke and Wheatstone introduced the telegraph into England, and invented certain means for carrying on telegraphy in a practical form, and they were the first to do this.

In 1835 Wheatstone exhibited to his class, in King's College, Schilling's single needle apparatus, and in the next year Sir W. Cooke became acquainted with that instrument at Heidelberg. The deep foresight and commercial spirit of the latter at once grasped the value of telegraphy to the railway world that was then springing into existence, and through the introduction of Faraday and Roget, Cooke and Wheatstone were brought into contact, and the ideas of each were amalgamated and perfected. In 1837 they produced the five needle or "hatchment" telegraph, which was subsequently modified into the double needle and finally into the present single needle instrument. In 1840 they produced an alphabetical dial telegraph. In 1841 Wheatstone produced alone a type printing telegraph and a new magneto-electric machine, and in 1845 Cooke and Wheatstone jointly patented several improvements and additions to their previous apparatus. Cooke about this period retired from the world of invention, but his partner never ceased to apply his active and practical mind to the improvent of the child that had now grown a giant. In 1858 and 1860 Wheatstone alone produced his beautiful A B C apparatus, and in 1858 his automatic apparatus, which was still further improved in 1867. It was while watching the progress of this last, and perhaps most perfect of his numerous inventions, that he was taken with that illness which proved fatal to him.

It is impossible to separate the names of Cooke and Wheatstone from the introduction of telegraphy into England and thence into the world, for it is idle to deny that its practical success in England preceded its introduction in any other country. The Americans claim the invention of his electro-magnetic telegraph for Morse in 1832. They are welcome to it; nevertheless, the first practical line was not put up in that country until 1844. The first line in England was constructed for practical purposes, paid for and worked by the Blackwall Railway in 1838. It was Cooke's indomitable energy, sanguine temperament, prac-

tical mind, and business habits which introduced telegraphy into England; and Wheatstone was the scientific man, whose profound knowledge, fertile intellect, and marvellous ingenuity enabled Cooke to surmount every difficulty. The two together forced telegraphy into existence against scepticism, conservatism, and inertia of the gravest character. It took fourteen years to establish telegraphy as a profitable business, and none but those who were engaged in the early struggles of English telegraphists know the energy, determination, and patience of the partner who followed his old and valued friend—from whom he had been separated for nearly thirty years, chiefly by the injudiciousness of friends — to his last resting-place, in Kensal-green, on that cold, raw, October morning.

In 1840, Wheatstone suggested submarine telegraphy, and drew up a scheme with wonderful prescience and prophetic skill to overcome the difficulties which were afterwards encountered. In 1843 he sent to the Royal Society "An account of several new instruments and processes for determining the constants of a voltaic circuit" — a paper which was the foundation of all exact measurements of electrical elements. In it he described the far famed Wheatstone's bridge, or, as he called it, the *differential resistance measurer*, which, though previously described by Christie, will always be known as Wheatstone's bridge, and he suggested a *unit* of electrical resistance sometimes known as Wheatstone's "foot," for it was a foot length of copper wire, weighing 100 grains. He also pointed out the use of the present universal "shunt" or "reducing wire" as he called it, and he designed the rheostat, or set of resistance coils. He gave during that year the Bakerian lecture on this subject.

In 1840 he invented his "Chronoscope," an instrument for measuring the duration of small intervals of time. It has been largely applied to measure the velocity of projectiles. It is composed of a clock movement, set free at the moment of the ball's exit from the gun, and stopped when it reaches the target. A wire at the gun's mouth is broken at the instant the ball passes out of the gun, and the circuit is completed the instant the ball reaches the target. This is the basis of all subsequent chronoscopes.

In 1843 he proposed to register meteorological observations, such as the temperature and pressure of the air, by the contact of mercury with a platinum wire in the tube of the barometer or thermometer; and his plan was extended to register the direction and force of the wind; the temperature and volume of water in a well; the temperature of a greenhouse; the number of visitors entering a building; the number of copies struck from a printing press, and numerous other useful actions.

In 1835 he read a paper before the British Association, in which he anticipated the modern science of spectrum analysis. He experimented on the bright lines of light emitted on the volatilisation of metals by currents of high potential, and showed that they differed in colour and position with every metal employed as an electrode. In 1838 he invented the Stereoscope, which, since the introduction of photography, has become a household drawing-room ornament and instrument. He showed that our conception of solidity was due to the mental union of two dissimilar perspectives. In 1852 he sent to the Royal Society a second paper on binocular vision, and described the Pseudoscope, an instrument which makes concave objects appear convex, and *vice versa*.

His last invention was a new recording instrument for submarine cables, formed by a globe of mercury moving to and fro in a capillary tube containing acid. It is said to be 58 times more sensitive than any previous recorder.

It is impossible even to summarise his wonderful exploits in the field of science. He experimented on every subject, from gyroscopes to captive balloons. The catalogue of the Royal Society contains thirty-one headings of his papers. Heat, light, electricity, sound, all received his attention at different periods. The Arctic ships, under Captain Nares, possess one of his most beautiful instruments—his *Polar clock*—which tells the time of day by the hourly changes in the plane of polarization of light. The Royal Institution in Albemarle-street and Burlington House are fitted up with his electric clocks. Every daily paper is indebted to his automatic apparatus for the news it prints. Every country squire is indebted to his magnetic A B C for the opening of the village post-office as a telegraph station.

He died full of honour. In 1836 he received the mystic letters, F.R.S. In 1855 he was made a Chevalier of the Legion of Honour. In 1873 he was made a Foreign Member of the Institute of France. He had no less than 34 foreign distinctions or diplomas, and in 1868 he was knighted.

Though his papers are the models of clearness and preciseness, he was a very poor lecturer, and though as a conversationalist on his favourite subjects he was unrivalled, his volubility forsook him in the face of numbers. His great exponent at the Royal institution was Faraday, who loved to lecture upon his friend's "beautiful developments," and one of whose last lectures in that celebrated arena was on the A B C apparatus.

His bibliographical knowledge was marvellous.

He seemed to know every book that was written, and everything that everybody had ever published. If any information was desired on any subject, there was no surer guide to fall back upon than Sir Charles Wheatstone. His power of deciphering hieroglyphics, puzzles, and cypher despatches, was something inexplicable. He seemed to divine the meaning of any paradoxical puzzle put before him instinctively; while, on the other hand, his ingenuity devised the cryptograph, or secret despatch writer, which is apparently inscrutable.

Wheatstone added no great fact to the science of Electricity. His mind was devoted not so much to probing the secrets of nature, like Faraday, as to turn those secrets discovered by others to practical use, not so much to develope news laws, like Ohm, as to verify those laws and turn them to useful purposes. He was essentially a practical man.

Many bright spirits and brilliant intellects have adorned this nineteenth century, but there is no name which, in the pages of the future, will shine with greater brilliancy than that of Charles Wheatstone. The great lesson to be learnt from the life of Wheatstone, like that from the life of Faraday, is that in the great Republic of Science birth and wealth are of no advantage to those who seek honour and renown. Every distinction which the State and the world could afford were showered on both, and each showed that intellect, aided by self-help and probity, will raise the humblest peasant into the highest positions of honour and respect.

BRIEF SUMMARY OF TELEGRAPHS PRIOR TO THE YEAR 1838.

Lesarge, in 1774, employed twenty-four wires and a pith-ball electrometer.

Lomond, in 1787, employed one wire and a pith-ball electrometer.

Betancourt, in 1787, used one wire and a battery of Leyden jars.

Reizen, in 1794, had twenty-six wires: the letters of the alphabet were cut out in pieces of tinfoil, and rendered visible by sparks of electricity.

Cavallo, in 1795, used one wire; the number of sparks was made to designate the various signals, and the explosion of gas was used for an alarum.

Salva, in 1796. The exact particulars of this telegraph are doubtful.

In all the above plans, high-tension electricity was to be employed.

Soemmering's telegraph, of 1809 or 1811. In this telegraph galvanic electricity was used, and as many wires were employed as there were letters or signals to be denoted. The letters were designated by the decomposition of water; an alarum was also added.

Schwieger employed the principle of Soemmering's telegraph, but reduced the number of wires to two. He also proposed the printing of the letters.

Coxe's telegraph, in 1810. Coxe proposed the use both of the decomposition of water and also of metallic salts.

Ronalds's in 1816. In Ronalds's telegraph high-tension electricity was employed. The wires used were laid under-ground as well as suspended in the air. A pith-ball electrometer, hung before a clock-movement, enabled the letters on a dial to be read off. The sounding of an alarum by exploding gas, &c., was also added.

Ampère, in 1820. Ampère employed the magnetic needle, the coil of wire, and the galvanic battery, and proposed the use of as many wires as letters or signals to be indicated.

Tribaollet, in 1828. Tribaollet's telegraph required but one wire, and this was buried in the earth. A galvanic battery and a galvanoscope were employed.

Schilling's telegraph, in 1832. Schilling employed five magnetic needles and had also a mechanical alarum. In another telegraph of Schilling's one needle and one wire only were used.

Gauss and Weber, 1833. In the telegraph of Gauss and Weber one wire and one needle only were needed. The power employed was magneto-electricity.

Taquin and Ettieyhausen, in 1836. The particulars of the telegraph of these parties are at present uncertain.

Steinheil's telegraph, 1837. This telegraph required only one wire and one or two magnetic needles. The power used was magneto-electricity. Steinheil had a printing telegraph as well as a means of telegraphing by sounds produced by electric apparatus striking bells.

Masson's telegraph, 1837 and 1838. In this telegraph magneto-electricity was employed in conjunction with magnetic needles.

Morse's telegraph, 1837. Morse's telegraph was a printing or recording telegraph; it required only one wire, and galvanic electricity was used. An electro-magnet of iron was used for attracting an armature, to which was attached a pricker or pen to mark paper, which was made to pass underneath it.

Vail's telegraph, 1837. This was a telegraph for printing the letters of the alphabet. One wire only was used. Clockwork mechanism, regulated by pendulums was also added.

Davy's telegraph, 1837. In this telegraph magnetic needles and coils of wire were used. The needles removed screens which previously rendered the letters invisible.

Alexander's telegraph, 1837. Thirty magnetic needles and thirty wires were required in this plan. Each needle removed a screen which obscured a letter painted behind it.

Previous to 1837 we have, therefore, no less than fifteen telegraphs, and in 1837 no less than six new arrangements of telegraphs, exclusive of the one of Messrs. Cooke and Wheatstone, which was patented in June, 1837.

In the Ordnance Survey, Southampton, engraved copper plates 3 ft. by 2 ft., and electrotyped by very large Smee cells, ⅓lb. of copper is deposited per square foot in 24 hours, and by raising the temperature, 1 lb. per square foot can be deposited in the same time.

The following remarkable anticipation of the Electric Telegraph is a copy from an Edition of Strada's Prolusions in the Bodleian Library at Oxford.

It is the basis upon which the Italians claim the Electric Telegraph as an Italian idea, brought into use by means of the inventions of Volta and Galvani—Italians.

" Famiani Stradæ Romani è Societate Jesu Prolusiones Academicæ
Juxta exemplar Authoris recognitæ, atque suis Indicibus illustratæ.
Oxoniæ, Excudebat Gulielmus Turner Academiæ celeberrimæ Typographus
MDCXXXI. Lib II. Prol: VI. Poet: Academia II. (p. 238.) "

" Lucretii stylus.

" Magnesi genus est lapidis mirabile, cui si
Corpora ferri plura stylosve admoveris; inde
Non modò vim, motumque trahent, quo semper ad Ursam,
Quæ lucet vicina polo, se vertere tentent:
Verùm etiam mira inter se ratione modoque
Quotquot cum lapidem tetigêre styli, simul omnes
Conspirare situm motumque videbis in unum.

Ferrei styli tacti a magneti servantes mutuum motum distracti distantesque.

Ut si fortè ex his aliquis Romæ videatur,
Alter ad hunc motum, quamvis sit dissitu longè
Arcano se naturäi fædere vertat.

Planus orbis literis circumscriptis.

Ergo age, si quid scire voles, qui distat, amicum,
Ad quem nulla accedere possit epistola; sume
Planum orbem patulumque, notas elementaque prima
Ordine, quo discunt pueri, describe per oras
Extremas orbis, medioque repone jacentem,
Qui tetigit magneta, stylum; ut versatilis inde
Literulam, quamcunque velis, contingere possit.
Hujus ad exemplum, simili fabricaveris orbem
Margine descriptum, munitumque indice ferri,
Ferri quod motum magnete accepit ab illo.

Ratio alloquendi absentum absque nuncio et epistola

Hunc orbem discessurus sibi portet Amicus,
Conveniatque priùs, quo tempore, queisve diebus
Exploret, stylus an trepidet, quidve indice signet.
His ita compositis, si clàm cupis alloqui amicum
Quem procul a tete terräi distinet ora;
Orbi adjunge manum, ferrum versatile tracta
Hîc dispôsta vides elementa in margine toto
Queis opus est ad verba notis, huc dirige ferrum,
Literulasque, modo hanc, modo et illam cuspide tange,
Dum ferrum per eas iterumque iterumque rotando,
Componas singillatim sensa omnia mentis.

Mira fides! longè qui distat cernit amicus,
Nullius impulsu, trepidare volubile ferrum,
Nunc hùc, nunc illuc discurrere: conscius hœret,
Observatque styli ductum, sequiturque legendo
Hinc atque hinc elementa, quibus in verba coactis,
Quid sit opus sentit, ferroque interprete discit,

Ratio respondendi eodem modo.

Quin etiam cùm stare stylum videt, ipse vicissim,
Si quæ respondenda putat, simili ratione,
Literulis variè tactics, rescribit amico.

Commoda hujus inventi."

O, utinam hæc ratio scribendi prodaut usu;
Cautior, et citior properaret epistola, nullas
Latronum verita insidias fluviosque morantes.
Ipse suis Princeps manibus sibi conficeret rem:
Nos, soboles scribarum, emersi ex æquore nigro,
Consecraremus Calamum Magnetis ad Oras!"

N.B.—Strada natus 1572, obiit 1649.

TRANSLATION.

There is a wonderful kind of magnetic stone to which, if you bring in contact several bodies of iron or dial-pins, from thence they will not only derive a force and motion by which they will always try to turn themselves to the bear which shines near the pole, but, also, by a strange method and fashion between each other, as many dial-pins as have touched that stone; you will see them all agree in the same position and motion, so that, if by chance one of these be observed at Rome, another, although it may be removed a long way off, turns itself in the same direction by a secret law of its nature. Therefore try the experiment, if you desire a friend who is at a distance to know anything to whom no letter could get; take a flat smooth disc, describe round the outside edges of the disc stops, and the first letters of the alphabet, in the order in which boys learn them, and place in the centre, lying horizontally, a dial pin that has touched the magnet, so that, turned easily from thence, it can touch each separate letter that you desire. After the pattern of this one, construct another disc, described with a similar margin, and furnished with a pointer of iron—of iron that has received a motion from the same magnet. Let your friend, about to depart, carry this disc with him, and let it be agreed beforehand, at what time, or on what days, he shall observe whether the dial-pin trembles, or what it marks with the indicator. These things being thus arranged, if you desire to address your friend secretly, whom a part of the earth separates far from you, bring your hand to the disc, take hold of the moveable iron, here you observe the letters arranged round the whole margin, with stops of which there is need for words, hither direct the iron, and touch with the point the separate letters, now this one, and now the other, whilst, by turning the iron round again and again throughout these, you may distinctly express all the sentiments of your mind.

Strange, but true! the friend who is far distant sees the moveable iron tremble without the touch of anyone, and to traverse, now in one, now in another, direction; he stands attentive, and observes the leading of the iron, and follows, by collecting the letters from each direction, with which being formed into words, he perceives what may be intended, and learns from the iron as his interpreter. Moreover, when he sees the dial-pin stop, he, in his turn, if he thinks of any things to answer, in the same manner by the letters being touched separately, writes back to his friend.

Oh, I wish this mode of writing may become in use, a letter would travel safer and quicker, fearing no plots of robbers and retarding rivers. The prince, with his own hands, might dispatch business for himself. We, the race of scribes, escaped from an inky sea, would dedicate the pen to the Shores of Magnet.

N.B.—Strada was born 1572 and died in 1649.

Note.—Addison, in the *Spectator*, No. 241, 6th December, 1711, alludes to Strada's idea as a "chimera," and which, but for the discovery of the Galvanic, or Voltaic-Battery, it might have remained.

ON THE TELEGRAPHIC PROBLEMS OF DOUBLE SENDING AND QUADRUPLEX TELEGRAPHY.

By G. K. WINTER,
Telegraph Engineer to the Madras Railway.
(Continued from page 236.)

PART II.

A SECOND method of double sending which I have successfully worked, follows, almost as a matter of course, from the system previously described.

presented by 3, will simply allow the local current to flow through both relays, and the double current represented by 4, will not only neutralise the local current in R¹, but will cause a current in it in the opposite direction to that in which the local current is flowing. Let both relays be polarised and so connected as to be worked by the local current. If now R¹ be a relay with two tongues, the position of rest of one of them being against the insulated stud, and that of the other against the central point; while the position of rest of the tongue of the relay R is against the insulated stud, and the

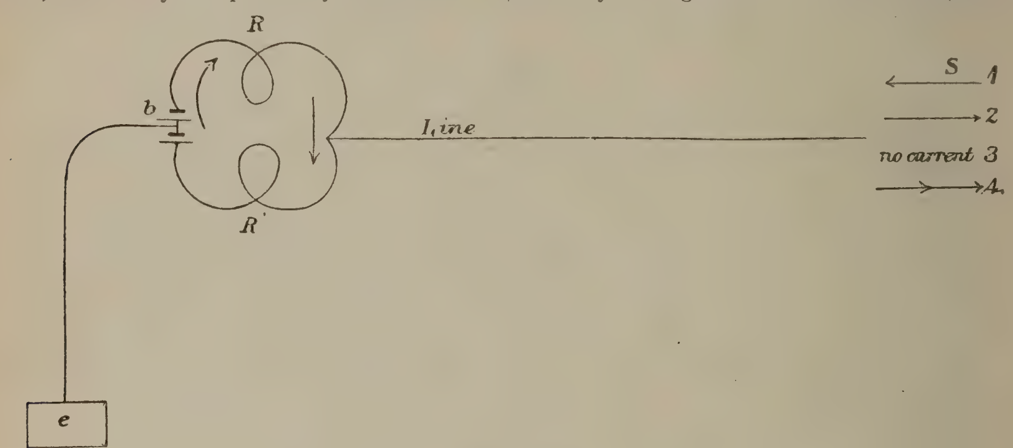

FIG. 12.

Let *b* be a battery, R and R¹ two relays, and let them be joined up with earth, and line in the manner shown on fig. 12. Let S be the distant station, and let the four combinations of the keys at that station produce the currents repre-

tongues joined up as shown by fig. 13, we shall have exactly an analagous action in the relays to that described in the first part of this paper. This system possesses certain advantages over the system previously described; it is simple in theory,

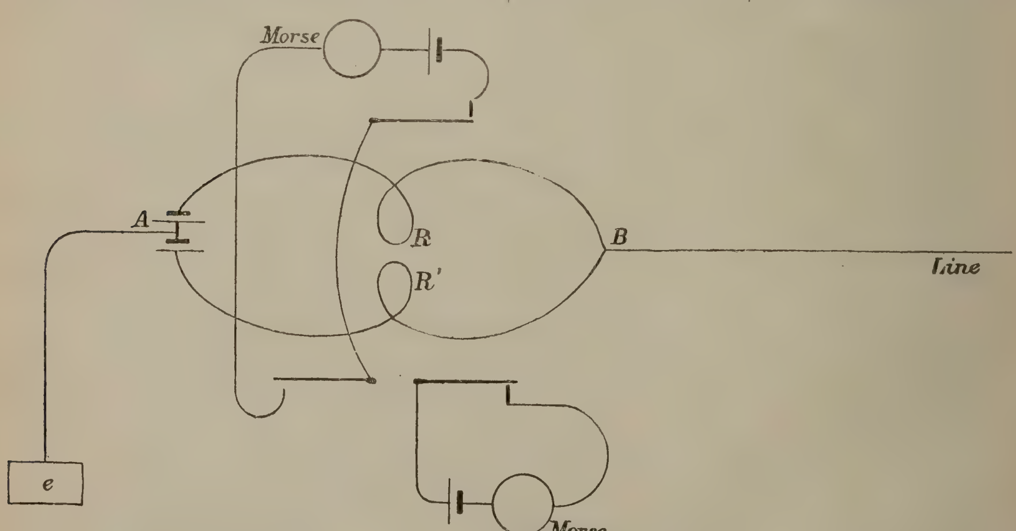

FIG. 13.

sented by the arrows, &c., opposite 1, 2, 3, 4, respectively. The current represented by the arrow opposite 1 will aid the local current through R¹, but will neutralise that in R. Again, the current represented by 2 will aid the local current in R, but will neutralise that in R¹. No current, re-

requires less battery power, and necessitates neither a differentially wound relay nor a bridge arrangement.

N.B.—The tongues are shown in their positions of rest.

This system works exceedingly well, and of

course the same arrangement of keys will suit either method. In order to duplex this system, we join the two branches of the bridge to the points A and B, and put a resistance coil between A and earth, adding condensers to this coil if necessary. Since the first part of this paper left, I have worked the quadruplex arrangements described without any difficulty.

It is very desirable that the currents should be properly balanced in the relays R and R[1], and it is also evident that the resistances of the two branches in which they are placed should be equal. In order to secure those conditions I make the following arrangements :—

terial, and the barrel E is of brass or other conductor; by turning the barrels equal increments or decrements are effected in the resistances of the two branches.

We will now analyse the changes in the positions of the tongues of the relays which are caused by the action of the keys.

Fig. 15 shows the position of the tongues and the direction of the currents when both keys are at rest. It is seen that both the tongues t t^1 of relay R[1] are open, while the tongue t^{11} of relay R is closed. Both local circuits are therefore open.

Now suppose that key to be pressed which causes a current ———> in the line.

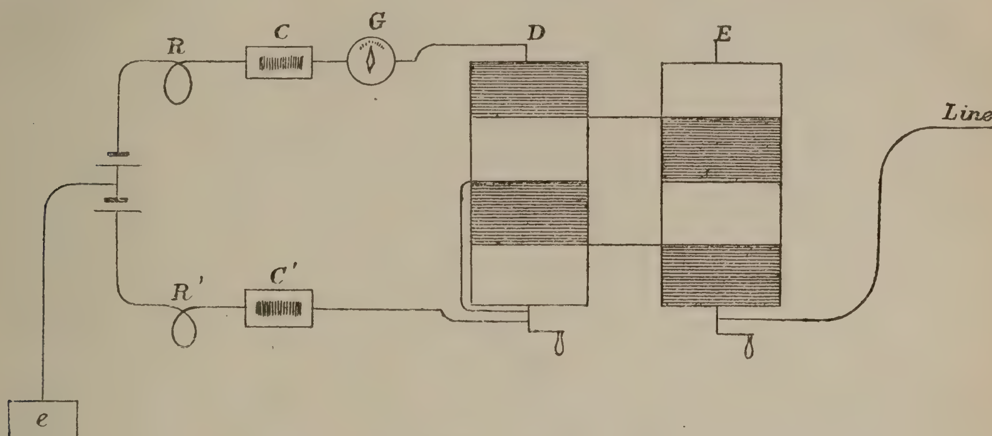

FIG. 14.

R and R[1] are the two relays as before, C and C[1] are two resistance coils for coarse adjustment, G

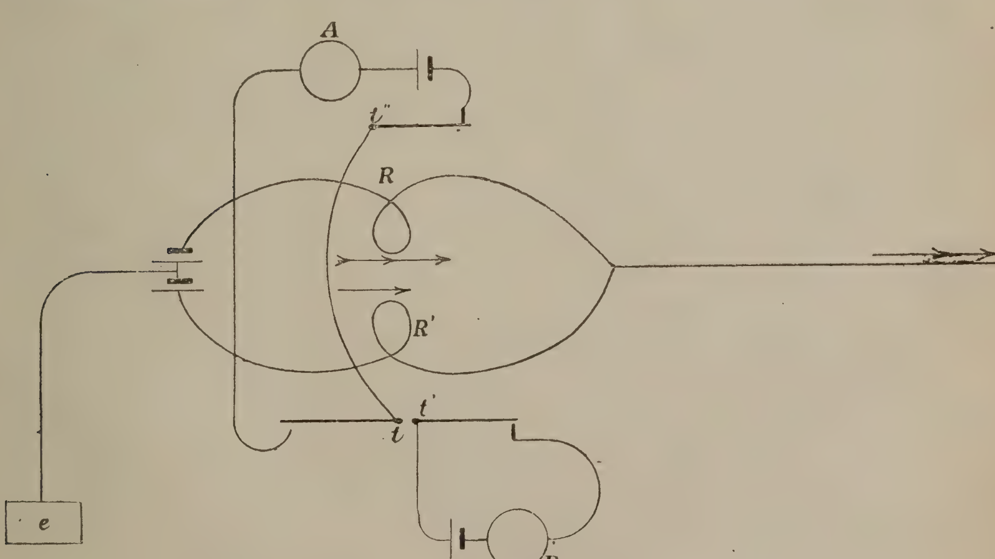

FIG. 15.

a galvanometer, and D and E are two barrels of a rheostat by which the finer adjustments are made; the barrel D is of ebonite or other insulating ma-

The current in R is simply reduced from three units to two units, so that tne tongus t^{11} continues closed. The current R[1] is neutralised, so that the tongue t falls to its position of rest against the contact points, and thus completes the circuit of

the Morse A. The tongue t^1 remains against the insulated stud, as that is the position of rest; the current of Morse B is therefore open. When the key is raised the tongue t simply falls back against the insulated stud, and thus breaks the circuit of Morse A. We will call this key A, and we see that it works the Morse A when it alone is worked.

Now let the key B be depressed, producing a current <—— in the line.

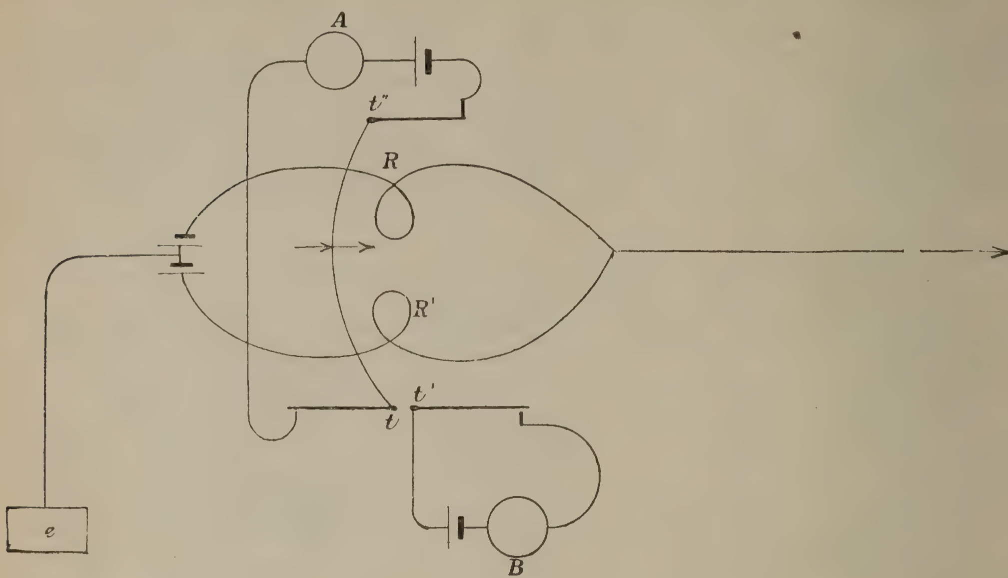

FIG. 16.

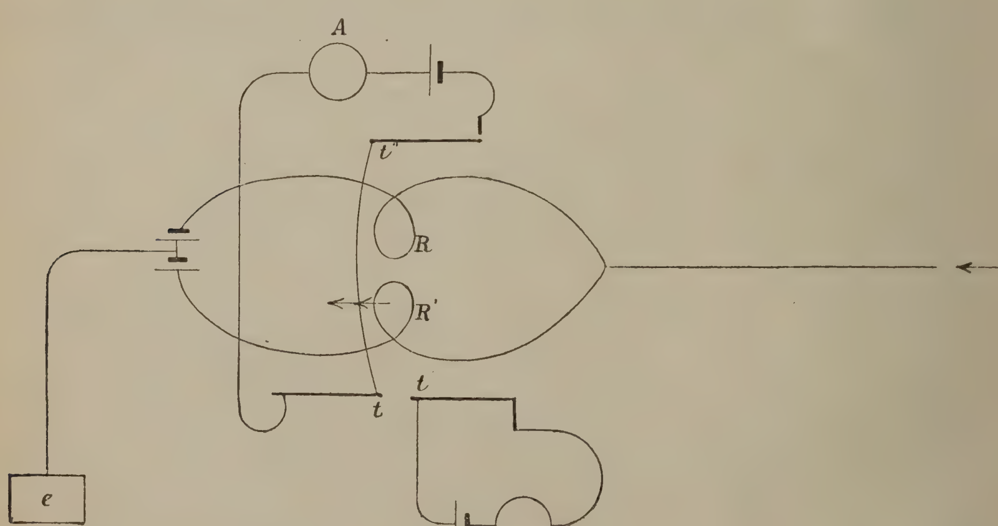

FIG. 17.

The current in R is now neutralised, while that in R^1 is two units in the direction of its working. The tongue t^1 closes the circuit of Morse B. The tongue t also comes against its contact point, but the tongue t^{11} of relay R is opened, and it is evident that the tongue t has to perform a journey before it reaches the contact point, while the tongue t^{11} breaks the circuit as soon as it begins to move, so that a little care in the adjustment is all that is

required to prevent any kick at this change. The same may be said when the key B is raised

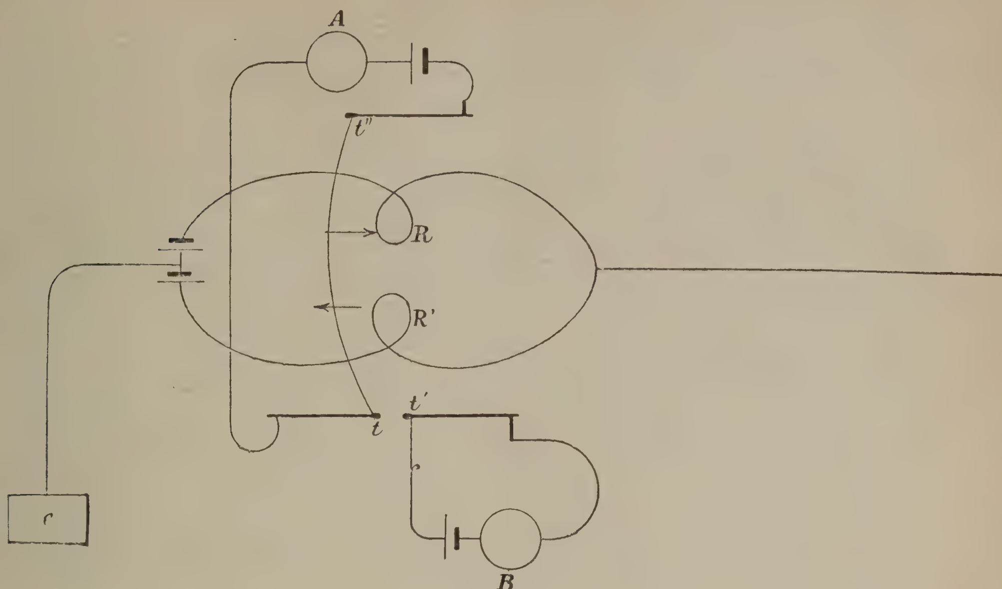

Fig. 18.

and the tongues go back to their normal position; the tongue t^{11} has to perform a journey before it reaches a contact point, while the tongue t breaks the circuit directly it begins to move. These are the only changes which involve the motion of more than one tongue at a time, and it is clear that a kick can only be produced in the event of one of the tongues t or t^{11} reaching its contact point before the other breaks the circuit by commencing to move to the insulating stud. Practically a little care is necessary to prevent this kick.

Next let us suppose the key A to be kept depressed, and that we work with key B. The current in the line which is ———> when the key B is up, becomes zero when key B is depressed. The position of the tongues when key A alone is depressed, is shown in fig. 16, both t and t^{11} are closed, and only t^1 is open. The reduction of the line current to zero produces the effect shown in fig. 18.

Thus the working of the key B while A is depressed, simply causes the closing and unclosing of the circuit of Morse B by the action of the tongue t^1.

Lastly, suppose the key B to be depressed and the key A worked. The state of things when B alone is depressed is shown in fig. 17, in which both tongues of relay R^1 are closed, and only the tongue of t^{11} of relay R is open. It is evident that the reduction of the line current to zero by the depression of key A, will simply cause the closing of the circuit of Morse A by the tongue t^1, and this tongue alone will fall back and open the circuit of Morse A when the key A is raised.

I hope to examine the American methods in a future paper; all I need say now is that they are open to the same objections as those pointed out in the earlier systems, and it is difficult to understand how success could possibly have attended their working.

Notes.

The Direct United States Cable was successfully repaired and communication re-established on the 4th instant. Both companies are now forwarding messages at the rate of 3s. per word.

The *Hibernia*, with the remainder of the New Zealand Cable, has left the Thames. She was unfortunate enough to run ashore in a fog, but got off without damage.

The traffic receipts of the Direct Spanish Telegraph Company (Limited) for the month of October were £1,580, against £1,386 in the corresponding period of last year.

From the 1st November the rate between London and any station in Spain by Direct Spanish Cable between the Lizard and Santander will be 7s. for a Telegram of 20 words.

At the adjourned meeting of Hooper's Telegraph Works (Limited), the report of the committee of investigation was adopted, and it was proposed to raise about £50,000 on debentures.

The receipts of the Submarine Telegraph Company for the month of October, 1875, amounted to

£10,918, against £9,910 for the corresponding month of last year.

The traffic receipts of the Great Northern Telegraph Company for the month of October amounted to 387,084f., against 420,885f. last year; and the total traffic receipt, from 1st January to 31st October amounted to 3,574,032f., against 3,748,925f. last year.

The Eastern Telegraph Company's receipts for the month of October amounted to £35,757, against £32,853 in the corresponding period of 1874; and those of the Eastern Extension Australasia and China Telegraph Company, to £19,604, against £16,584 for the corresponding period of 1874.

Few bodies are more easily electrified than collodion. With the least friction by the hand, the membrane adheres to the fingers. If a collodion sheet be fixed, like a flag, to a glass tube, and waved in dry and hot air, it is electrified.

Mr. Moxon has introduced, on the Lancashire and Yorkshire Railway, a new right and left Morse printing apparatus. The characters are not made in dots and dashes, but in dots only, on different lines, in what is known as Steinheil's Alphabet. The messages as recorded are very compact and legible, and there can be no doubt that considerable speed is gained. It is in use on a busy single needle circuit, for it is worked by the same means and by the same alphabet as the single needle instrument.

Prof. Palmieri has discovered a new instrument which he calls the "diagometer," and which is constructed for the rapid examination of oils and textures by means of electricity. What the apparatus will do Prof. Palmieri details thus: 1. It will show the quality of olive oil. 2. It will distinguish olive oil from seed oil. 3. It will indicate whether olive oil, although of the best appearance, has been mixed with seed oil. 4. It will show the quality of seed oils. 5. Finally, it will indicate the presence of cotton in silken or woollen textures. The professor has been complimented for this invention by the Chamber of Arts and Commerce at Naples, who have published a full description of the apparatus, with instructions for use.—(*Nature.*)

In an amusing article on "Insular Egotism" the *New York Telegrapher* gravely publishes the following interesting information:—In no other country has telegraphy acquired such perfection in actual use or been so universally adopted and used by the people as in the United States and Canadas. More actual business is transmitted daily on a single circuit by two operators in this country than by four operators on two circuits on the English lines. Business is dribbled over the English lines slowly by means of needle telegraphs or by Morse registers, the use of which is universal there but exceptional here; and the automatic telegraph of Wheatstone gives a speed of seventy to eighty words per minute in actual business against 1,200 to 1,500 words per minute by the American automatic system.

The use of ebonite, one of the newer preparations of Indiarubber is constantly increasing, on account of its better applicability to many purposes in the arts than its near ally, vulcanite. The two substances are quite similar, being composed of Indiarubber and sulphur, with some preparation of gutta percha, shellac, asphalte, graphite, etc.; although these latter are not essential. In vulcanite the amount of sulphur does not exceed 20 to 30 per cent., whereas in ebonite the percentage of sulphur may reach as high as 60. An increased temperature is also required for this preparation. The approved formula consists in mixing together 100 parts of rubber, 45 of sulphur and 10 of gutta percha, with sufficient heat to facilitate the combination. In manufacture, a sufficient quantity of this mixture is placed in a mould of a desired shape, and of such material as will not be affected by the sulphur contained in the mass. It is then exposed to heat of about 315°, and a pressure of about 12 pounds to the square inch, for two hours. This is done most readily by placing the mould in a steam pan, where the requisite pressure and temperature can easily be kept up. When cold the ebonite is removed from the mould, finished and polished in the usual manner.—(*Journal of the Telegraph*).

In our number for the 16th of April last we made mention of a new system of rapid and simultaneous telegraphy, the invention of Major Barney, an American, which had been tried on the Government lines and found to give very satisfactory results. Since that time, agreeably to Mr. Barney, some modifications have been made in the system by Mr. Godener, a Frenchman and pupil of Bréguet, and later experiments have given still more satisfactory promise than those made at first. The following are some of the results:—On the 1st of July, the same dispatch was transmitted simultaneously to Ostend and Antwerp from Brussels, with a velocity of 600 words a minute. These trials took place on the lines between Brussels and Ostend and Brussels and Antwerp, the lines having been joined at Brussels in order to obtain increased length of circuit; the first was 156 miles, and the second about 57 miles long. July 17th, messages were sent from Ostend to Brussels with a velocity of 1,092 words per minute (all being read by the employés present). August

25th, messages were transmitted from Brussels *via* Arlon and back, a distance of about 237 miles, at a velocity of 600 words per minute and read by the employés of the office. There is reason to congratulate the railroad, post and telegraphic administration for having, in the interest of science and progress, placed their lines at the disposal of the experimenters.—(*L'Independence Belge*).

The Count du Moncel, our readers may be aware, has been engaged some time in studying the electric conductivity of substances that are but moderately good conductors. In his last note to the Paris Academy on the subject he states the following conclusions he has arrived at: 1. The metallic minerals, when they have a certain degree of conductivity, generally give, when under the influence of heat, thermo-electric effects, and this increases or diminishes the conducting power of the mineral according as its resistance is greater or less. 2. Some metallic minerals may present electrostatic and electrotonic effects (so remarkable in hard stones—silex in particular), but with these are joined effects from thermo-electric actions, which generally predominate; in all cases these minerals are not impressionable by the moisture of the air. 3. Such minerals are comparatively resistant, but less than ordinary stones, and consequently the heat increases their conductivity. 4. Minerals which have a great metallic resistance, and have not a well-developed electrostatic capacity, present a very weak metallic conductivity, but they give sensible thermo-electric currents and heat slightly increases their conductivity. 5. Minerals which only possess a well-developed metallic conductivity give intense thermo-electric results, but the heat diminishes their conductivity and the effects resulting from electrotonic conductivity are not met with.

It is proposed to hold an Electrical Exhibition in Paris in 1877. It will be held in the Palais de l'Industrie, the object being to illustrate all the applications of electricity to the arts, to industry, and to domestic purposes. This project, which was initiated by Count Hallez d'Arros, has been received with general favour both by the scientific and industrial worlds, and the necessary funds have been already guaranteed. An organising committee is formed, and the provisional offices of the Exhibition have been established at 86, Rue de la Victoire. This committee has held its first general meeting at the Palais de l'Industrie, Paris, under the presidency of Colonel Laussedat, one of the delegates appointed by the French Minister ef War. The committee approved the regulations proposed by Count Halley d'Arroz, the originator of the scheme, appointed him general director, and divided the exhibition into eighteen groups. Amongst these are the History of Electricity, a section in which will be collected, as far as possible, the instruments which were used by Davy, Faraday, Volta, Arago, Ohm, Oersted, Ampère, and others, in making their discoveries. The eighteenth group will be Bibliographical; a library as complete as possible will be formed of all the books and papers published in the Transactions of the several Academies, and scientific periodicals relating to electricity. A requisition will be sent to the administration of the National Library, asking them to offer, for 1877, their systematic Catalogue of Electricity. The President of the French Republic will be the head of the Committee of Patronage, and a sub-committee has received instructions to open negotiations with foreign *savants* and Governments.—(*Nature.*)

Under date of Sept. 5th the *New York Herald's* correspondent at Lima, Peru, writes concerning telegraph matters in Peru, Chili, and Bolivia, as follows:—The *Dacia* and *International*, steamers in the service of the I. R., G. P. and Telegraph Works Company, have successfully concluded their work on the coast, and a submarine cable now connects Chorillos, a watering place nine miles from Lima, with Caldera, in Chili, whence telegraphic communication may be had, *via* Valparaiso and Santiago, with Buenos Ayres and Montevideo, and from these last-named cities to Europe and North America by way of Rio Janerio, Bahia and Lisbon. The coast line touches at Mollendo, Arica and Iquique, passing then to Bolivian territory at Cobija, and thence to Caldera. The first messages were despatched by Mr. Pardo to the Presidents of Chili and the Argentine Confederation, and to the Emperor Don Pedro, of Brazil, congratulating them upon the new link established between the respective countries. The enterprise should prove to be a profitable one, but the tariff now fixed is so excessive that the privileges afforded by the cable are, *ipse facto*, placed beyond the reach of the great majority of merchants. Even for despatches between the coast stations of Peru a charge of twelve hard dollars for ten words is exacted, making correspondence more than expensive. A curious feature is to be noticed, however. The Minister of the Interior, in a circular addressed to the different prefects, sub-prefects, and other officials of the government in the South, orders them in their communications sent over the wire to suppress all ceremonious terms, and even to address the President of the Republic as a simple, private citizen, leaving out the interminable "Your Excellency," and "May God keep you under his protection for years to come." It is shrewdly suspected here that this order of the Minister is

by no means agreeable to the telegraph company, as their profits will be notably diminished thereby; but the wishes of the Secretary are paramount.

The soundings for the projected cable between Sydney, New South Wales, and Wellington, New Zealand, which have been in progress for some months past by H. B. M. Ship *Challenger*, show that no unfavourable conditions exist in regard to the suitability of the route and the character of the bed. Captain Nares, of the *Challenger*, has communicated the following report to Sir Hercules Robinson, Governor of New South Wales, as the result of the survey :—On the Australian coast the incline from the 100 fathoms line, which was 17 miles from the land, into a depth of 2,100 fathoms at 57 miles distance, was about 1 in 20, which is less abrupt than we had previously found to be the case further to the southward of Twofold Bay, where it was about 1 in 6. The bottom, which consists of soft ooze, then slopes down to a depth of 2,600 fathoms, at a distance of 240 miles from the coast, the temperature being 33 deg., which conditions continue for 140 miles. From this extreme depth the bottom slopes upward, with a gentle incline, with soft ooze, for 400 miles, until at a position 780 miles from Sydney and 335 miles from the entrance to Cook's Straits we obtained soundings in 1,100 fathoms. Between this and New Zealand only shallow soundings below 400 fathoms, with hard bottom, were obtained. The most westerly of these, 275 fathoms, was 300 miles from the land and 125 miles to the eastward of the 1,100 fathoms sounding. The shoal water evidently extends for some distance further to the westward, probably as much as 100 miles, which would give a total breadth of shallow water of 300 miles. The bottom on the shoal was extremely hard, so much so that we obtained little or no samples in the sounding rods; but as both the dredge and trawl dragged freely along, without catching any irregularities, it must have been of a smooth nature. On reference to former soundings on the general chart it is evident that a somewhat similar bank extends for a considerable distance to westward of the north cape of New Zealand; such being the case, the shoal is probably continuous, and shallow water may be expected all along the western side of North Island, but I see no reason to suppose that deep water does not extend to within a very short distance of the southwest cape of the Middle Island, which is also the nearest land to Australia.

During the past two weeks, Mr. Elisha Gray of Chicago, Ill., has been exhibiting his electro-harmonic apparatus in the Western Union Building, in this city. More than a year since we published an article descriptive of this curious discovery, so far as it had been developed at that time. Since then Mr. Gray has devoted the greater part of his time to the perfection of the apparatus, and has already succeeded in producing some very remarkable results. Mr. Gray's earlier experiments disclosed the fact that composite tones were as easily transmitted over a wire as single notes, and from this discovery he developed a system of multiple transmission, founded on this principle. The apparatus was tested experimentally on a wire between Boston and New York, on September 11th, with very satisfactory results. Four separate communications were simultaneously transmitted from Boston, and copied from four sounders by a like number of receiving operators in New York. In the main the signals were perfectly received on all the instruments, the only apparent defect being a tendency to shorten them somewhat, a difficulty which can doubtless be overcome by a suitable modification of the transmitting apparatus. The principle of the apparatus is a very simple one. Depression of each key sets a self-vibrating electrotome in operation, which is adjusted or tuned to vibrate at a certain rate, differing from that of any of the others, when under the influence of the electro-magnet controlled by its corresponding key. These several sets of electrical vibrations are transmitted through the circuit without interfering with each other, in the same manner that almost any number of different sets of sound waves may pass through the air without mingling. At the receiving station, each instrument is so adjusted as to respond to its own special sets of waves or vibrations without regard to others. By breaking and closing the circuit upon the transmitting electrotome, so as to form telegraphic signals, these are transmitted and taken up by the corresponding receiving apparatus. It is not easy to fix a limit to the number of different communications that may be carried on over the same wire simultaneously, either in the same or opposite directions. The marked success which has attended the operation of the principle through two hundred and forty miles of line, on September 11th, seems to promise results in the future of the greatest value.—(*Journal of the Telegraph.*)

Proceedings of Societies.

SOCIETY OF TELEGRAPHIC ENGINEERS.

THE Society of Telegraph Engineers resumed their meetings at the Institution of Civli Engineers on Wednesday the 10th inst., Mr. LATIMER CLARK, President, in the chair. After the reading of the minutes several associates were passed to the degree of member, and a large number of new

candidates was announced. The President then referred to the progress of the Society, and drew especial attention of the meeting to the life and works of the late Sir Charles Wheatstone, a member of the society. Subsequently a vote of condolence was passed to the family.

A paper was then read—"On the respective "merits and durability of Guttapercha and India-"rubber joints," by Mr. HENRY MANCE, of which the following is an abstract:—

The following experiments were conducted at the head quarters of the Persian Gulf Telegraph department, Kurrachee, with the view of ascertaining the extent to which the different descriptions of joints might be relied on. The results obtained are communicated by the desire of the Director-in-Chief, in the hopes of eliciting further information on the subject from the Members of the Society of Telegraph Engineers.

Between fifty and sixty joints were submitted to observation. The jointer, who has had several years' experience, was aware that they would be carefully examined, and I have every reason to believe that great care was taken in preparing them.

It having been suggested that guttapercha joints are more liable to perish when exposed to the influence of water in the cable tanks, 9 joints were submerged in the Kurrachee Harbour for six months; the deterioration, however, was about the same as that previously noticed in those kept carefully wetted in the tanks.

The insulation of the Fao-Bushire guttapercha cable, which has scarcely been touched since it was first laid, is higher now than it has ever been, leading to the inference that guttapercha joints made in the factory at home, when the core was new, are not subject to such a decrease in their insulation resistance as is shown in those recently examined at Kurrachee. The question arises whether guttapercha a few years old can be jointed so successfully as that in newly-manufactured core. I do not speak of core, the outside coating of which is perished, but sound core, which, although well preserved, has been manufactured say five or six years. Should a joint properly made in good core of this age retain for twelve months the high resistance it shows when first tested?

Mechanically the *whole* of the joints were good and sound; there was no outward sign whatever to indicate any deterioration, and when cut open the workmanship appeared perfect.

The second indiarubber joint is the only one of that kind which tests low, but this is due not to bad jointing but to a small perforation in the core made by a "borer" whilst the joint was submerged in the Kurrachee Harbour. It is worthy of note that out of a large bundle of joints only one indiarubber joint was touched by the borer, and in this case it had not quite penetrated through to the conductor. Many of the guttapercha joints in the same bundle were riddled with holes by borers in the same time.

Thinking it possible that guttapercha joints might have stood the test of time better with less manipulation during manufacture, I had joints made with greater dispatch. The latter joints tested the best. It is very probable that joints are as often injured by over care as by too hasty manufacture. There is a point beyond which manipulation and the use of the spirit lamp will do positive harm.

The observations have already extended over a period of more than two years; several joints were cut open, but the whole of those included in the list have, with one exception, been replaced in the tanks for further examination.

REMARKS ON THE CONSTRUCTION OF LIGHTNING PROTECTORS FOR TELEGRAPH WIRES.

By F. SCHAACK,
Secretaire à la direction des Télégraph à Cologne.
(From the *Journal Telegraphique.*)

THE lightning protectors employed by the various telegraph departments differ considerably as to form, but their principle is the same, whether it is based on the system of points or plates. Their common object is to offer to the lightning which strikes the line as short a passage as possible to earth, and so protect the apparatus from its destructive effects.

The construction of lightning protectors with points or plates in the forms most generally adopted is respresented below by figs. 1 and 2.

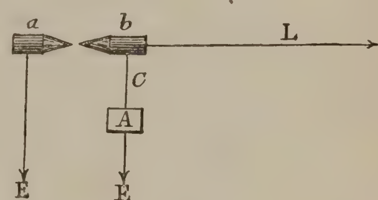

FIG. 1.

In fig. 1, *a* and *b* represent two metallic cones, the points of which are separated by a space of 0.5 mm.; *c* is a resistance formed by a wire of German-silver, which connects the instrument A with the cone *b*, that is to say with the line L. The cone *a* and the instrument A are connected to earth E.

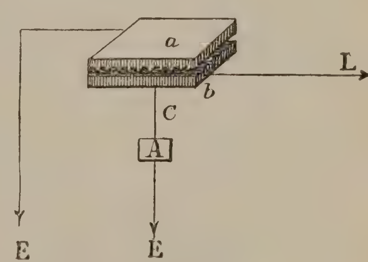

FIG. 2.

When the lightning traverses the line L it melts the resistance wire *c* (A is thus protected by being cut out of circuit) and leaps from *b* to *a*, and so escapes to earth.

In drawing No. 2, *a* and *b* represent two plates of metal laid very close together, the one above the other; their inner surfaces are grooved and insulated from one another by a sheet of paper; the grooves in the two plates cross each other, and by so doing form a series of points, offering a

more ready escape to the lightning. The other connections correspond with those in fig. 1.

This principle is in itself very simple, but when applied to a lightning protector, constructed to protect several wires, the numerous terminals for the connections with the line earth, instruments, &c., and the connections for ordinary working, as well as for the exclusion of the apparatus during storms, render the system very complicated, and liable to cause a great many faults.

The protectors, in fact, occasion faults which are for the most part to be attributed not only to atmospheric discharges, but rather to loose connections at the terminals, rupture of wires, short circuits produced by the proximity of the wires to the large mass of metal, and by moisture, which often connects the points, owing to the distance separating them being so small.

The first cost of fitting up is considerable, and reaches at least 25s. per wire, which, considering the number of stations, means the ex- penditure of considerable capital in fitting up.

On the other hand, the lightning in passing from one point to the other often fuses the points or melts them together. The repairs of these latter damages necessitate extra expenditure, inasmuch as they cannot be performed by the clerk, but require a skilled mechanic, which occasions considerable inconvenience to the service.

A lightning protector of the following construction remedies all these defects, and fulfils not only the desired object, but is a thoroughly practicable system; and on the other hand does not necessitate at most an outlay exceeding 25s. for a hundred wire protectors, and no expense for repairs, the clerk himself being able immediately to repair the damage done dy the storms. The most convenient position for the protector is near the batteries, so that the lineman, who looks after them, can at the same time see that it is in good working order. Figure 3 represents its construction in plan and section.

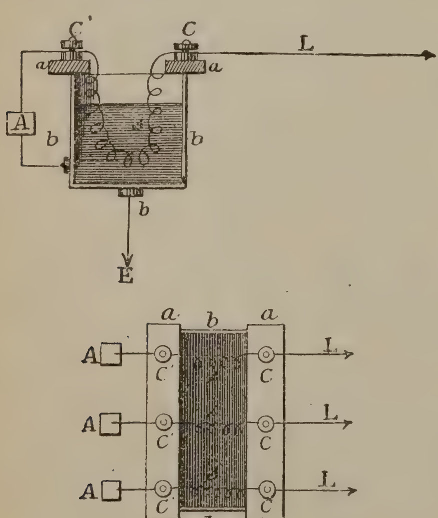

FIG. 3.

To the two sides of a cast-iron box *b b b*, about 10 centimetres in depth and the same in breadth, are fittted two strips of ebonite, *a a*, carrying the terminals for communication *c c'*. The line L is connected with the terminal *c*, and communicates by means of the terminal *c'* with the instruments A, which are connected underneath to the box of cast-iron and so to earth E.

The terminals *c* and *c'* are connected together by a German-silver wire (*s*) made into a large spiral. The wire is covered with silk, and dipped several times in a solution of Indiarubber, so as to form an insulating covering impermeable to water. The iron trough should be placed in the battery-room, on a floor affording a good earth connection, or else connected to earth by some other convenient method, and should be three parts filled with water.

Now when the lightning strikes the line the wire *s*, with its thin insulating covering, offers a very direct connection with the water, and so to earth; the spiral *s* will be fused or the insulating covering pierced, and will thus open a direct circuit to earth. As the ends of the broken wire might perhaps come in contact with the sides of the box, and so convey a portion of the atmospheric discharge through the instruments, it is preferable not to put them direct to earth, but to find earth by means of the iron box; by this foresight they will be completely out of danger from the discharge of the lightning.

After the storm the clerk replaces the broken wire by one in reserve, and the damage is repaired. The length of the iron box depends on the number of wires to be protected; a space of two centimetres will suffice for each. It must be remembered that this new form of protector will appear very primitive as compared with those generally in use, which are in themselves an ornament to our offices, and rank high in the opinion of those not versed in telegraphy, but as regards practical use and economical advantages we believe it fully deserves preference to any other form.

THE EGOTISM OF IGNORANCE.

(From the *Journal of the Telegraph.*)

WE published in our last issue that portion of the inaugural address of Sir John Hawkshaw, the newly elected President of the British Association for the Advancement of Science, in which he professed to outline the history of the electric telegraph.

The Society numbers amongst its members some of the foremost scientists of the day. It stands prominent in the front rank of similar bodies in the world of civilisation, and its discussions, deliberations, and decisions are read and regarded as authoritative by learned men in all countries.

The address of Sir John Hawkshaw, so far as it relates to telegraphy, is chiefly remarkable for what it does not contain. In no country more than the United States is the great truth acknowledged that science has no nationality—that it is cosmopolitan—and until this remarkable production appeared, and for which its author received the official thanks of his associate members, it was hoped that the scientists of Great Britain were in no whit behind in their acknowledgment of what was due to those who worked in the same field, but who, in the eyes of the average Briton, laboured under the disadvantage of not being born on British soil.

Comparisons are odious; yet we believe that the names of American discoverers and inventors which are comprised in the term "others" and tacked on to the tail end of the name of Sir Charles Wheatstone, will compare favourably with any furnished by Europe, and particularly by Great Britain, in the unparalleled advancement of electrical and telegraphic science which the last quarter of a century has witnessed.

AN EXPERIMENT FOR SHOWING THE ELECTRIC CONDUCTIVITY OF VARIOUS FORMS OF CARBON.

By H. BAUERMAN, F.G.S.*

(From the *Philosophical Magazine.*)

THE following simple method of exhibiting the conducting power of carbon was brought to my notice by my friend Mr. W. J. Ward, of the Metallurgical Laboratory of the Royal School of Mines, as having been shown to him several years since by Dr. von Kobell, of Munich. As I have not found any account of it published, I have ventured to bring it before this Society.

A fragment of the substance to be tested, whether charcoal, coke, anthracite, or other form of carbon, is held between the jaws of a pair of tongs formed by bending a strip of sheet zinc into a horse-shoe form, and immersed in a solution of cupric sulphate. If the carbon is a non-conductor, the copper salt is decomposed, and deposit of copper only takes place on the immersed surface of the zinc; but when it possesses a high degree of conductivity a zinc-carbon couple is formed, and deposit of copper takes place on the surface of the carbon as in ordinary electrotyping.

Of the different forms of carbon experimented upon, the most rapid results have been obtained with some American anthracites, and coals that have been subjected to the action of intruded igneous rocks. The most remarkable of these is an anthracite from Peru, which contains a large amount of sulphur in organic combination, and is found in a nearly vertical position, interstratified in quartzite, in the high plateau of the Andes, about 13,000 feet above the sea-level, near Truxillo. It is probably of secondary age, the metamorphism having taken place at the time of the great trachytic outbursts which form the gold-and-silver-bearing rocks of the adjacent mining-district. This is coppered by immersion almost as readily as graphite. The anthracite of Pennsylvania possesses the same property, but not in quite such a high degree. The heathen coal of South Staffordshire, when altered by the intrusion of the "white-rock" trap, is more slowly coppered; but this is probably due to the resistance interposed by the numerous laminæ of calcite filling the fractures in the mass of the coal, which renders the conductivity less perfect. A specimen of coal from Bengal, altered in the same manner by intrusion of igneous rock, behaves much in the same way as coke, being coppered directly. This is rather remarkable, as this coal is a very impure one, and contains such a large quantity of water very intimately combined, probably as a hydrated silicate interspersed through the mass, as to decrepitate explosively when suddenly heated.

The ordinary Welsh anthracite does not appear to be a conductor by this method, but after having been heated to a full red heat it conducts electricity freely. The lowest temperature at which this change takes place appears to be somewhere between the melting-points of zinc (430° C.) and silver 1000° C.), as fragments of anthracite packed in a thin clay crucible and plunged into molten zinc were not found to be altered, but were changed when heated in a bath of melted silver. These limits, although considerably wide apart, are interesting as giving a possible clue to the temperature at which anthracite metamorphism of coals has been effected in different districts. Mr. W. C. Roberts has recently shown that the alloys of silver and copper have very definite melting-points; it will be possible therefore to determine more nearly the lowest temperature necessary to produce the change.

In the South Wales anthracite district it is well known that no great amount of disturbance has taken place in the position of the coal-seams, while in North America and Peru the change has been accompanied with much more violent action, as evidenced by the greater disturbance of the rocks; and probably a correspondingly higher degree of heat was developed in the mass. The evidence afforded by the coals that have been actually altered by intruded rocks, and must have been highly heated, appears to bear out this view. On the other hand, long-continued exposure to a lower temperature might possibly produce the same effect, and further experiments upon this point would be desirable.

* Read before the Physical Society, May 22 1875.

THE ELECTRIC LIGHT.

SINCE Sir Humphrey Davy exhibited the electric light for the first time in England at the Royal Institution, more than half a century ago, it is surprising what little practical use we have been able to make of this most brilliant source of illumination. It has been employed from time to time for illuminating works at night, and has also been adopted in one or two lighthouses—that of the South Foreland, for instance, where the spark, at a distance of thirty miles, looks like a star of the first magnitude; but the difficulty of securing a constant light has always stood in the way of a widespread application of so valuable an illuminating agent. One main difficulty connected with the matter was surmounted by Faraday when he discovered that electricity could be induced by magnetism, and thus we are enabled at the present day by simply turning a handle and causing a series of armatures to revolve in front of magnets, to produce a light as vivid and intense as that which in the days of Sir Humphrey Davy necessitated a battery of four thousand metal plates. But we have made little progress in respect to the electric lamp itself, and there is still the same difficulty as of old in maintaining a constant spark between the two carbon points of the apparatus, although the interruptions are certainly far less frequent than they used to be. In the condition, however, in which the electric light is at present, there should be many useful appli-

cations of it to be found, and we are glad to see that the Lords of the Admiralty, in making their present tour of inspection, looked with much favour on some electric experiments made on board the *Minotaur* at Portsmouth. Among other things, it was shown that a vessel provided with an electric light could detect the approach of a hostile craft, no matter what colour it was painted, at a distance of a mile; and further, that the grey paint which covers the sides of many of our war vessels, and which was supposed to be the most invisible of colours, stands out with particular clearness when illuminated by electricity. An electric lamp would therefore be an element of safety in preventing the approach of torpedo-launches and such like dangerous craft without being observed, and the beam of intense light would serve also for signalling at night with a battery on shore, or with other vessels of a fleet or squadron. The Admiralty, we are told, have ordered further trials with the light, and if favourably reported upon, we may hope to find all our ironclads provided with an electric lamp. In the case of a dense fog, such as that prevailing at the time the *Vanguard* was struck, such a light would be particularly valuable.—(*Daily News.*)

TELEGRAPHIC PROGRESS IN AMERICA IN 1874-5.

(From the *Journal of the Telegraph.*)

The sum of the progress of the electric telegraph in the United States is comprised in the history of the Western Union Telegraph Company, and this is fully illustrated and set forth yearly in the reports of the president of that company to the stockholders. In the report for 1874-5, Mr. Orton presents a very flattering exhibit of the financial condition of the company, upon which there is no occasion for comment except it be as a subject for congratulation. But to its character as a record of the progress made during the twelve months embraced in the report we desire to call attention.

We find that on June 30th the company were operating 6,565 offices, with 179,294 miles of wire upon 72,833 miles of poles. The comparatively small increase in mileage over previous years, however, is only an apparent one. The actual increase has been not less than 30,000 miles of wire, evoked, as it were, out of nothing. The improved apparatus introduced, in doubling and quadrupling the carrying capacity of a wire, has virtually materialized a "phantom," as Mr. Orton aptly terms it, and which materialization is utilized without any expense for maintenance. The benefits of telegraphic communication have been conveyed to 377 places which heretofore had been without this convenience. This number is a little below the average of the previous eight years, but it is to be accounted for in the almost complete cessation in the construction of railways and the consequent decrease in the formation of new towns and settlements. The number of messages transmitted, shows an increase of 824,454 over the preceding year; the total number being 17,153,710. The number of telegraphic money transfers, a service of great value to the public, and which is peculiar to the Western Union Company, has largely increased. About 2,000,000 dols. was received and paid out at the various offices.

But it is in the question of rates charged for transmission that the public have the greatest concern. The report shows that even with a reduction in expenses to the extent of over $420,000, as compared with the previous year; the actual cost of handling a message between points distant from one to twenty-five miles, is not less than twenty-six cents. This important fact alone proves the impossibility of successfully establishing a postal system at a uniform rate of twenty-five cents to all points of the country, which was the rate fixed upon by the advocates and promoters of those pernicious schemes, and upon which was based the expectation of popular support.

Since 1867, the yearly average increase in the number of messages transmitted has been twenty-four per cent., and during the same period the tolls have been reduced fifty-one per cent. This reduction is greater in the aggregate than has ever been made upon the entire traffic of any other telegraph system in the same period of time.

Altogether the telegraphic interests of the country could hardly be in a better condition. Invention is encouraged, and improvements are welcomed. The eminently wise and sagacious policy pursued by the leading Company affords entire satisfaction to the public. These facts and the certainty of their continuance presents an augury of the future promising in the highest degree.

Correspondence.

AN IMPROVEMENT IN MORSE APPARATUS.

To the Editor of the Telegraphic Journal.

Sir,—When a Morse spring breaks, four or five of the teeth on the barrel, and occasionally other wheels follow *en suite*, caused by the violent expansion of the spring and consequent rebound of the drum. To prevent this extra damage we must either stay the expansion of the spring or allow it to run down free of the other clockwork. The latter may be effected by having the pinion (in which the teeth of the barrel work) tapped, and screwed on its axle in such a manner that the rebound of the drum unscrews the pinion which would be left loose on the axle, and thus allow the spring to run freely down and do no other damage. Of course, this arrangement will not prevent the breaking of springs, but it will avoid all damage arising therefrom.

This could easily be applied to the present instruments at a trifling cost, and would, I think, be an improvement.

H. G. Cheesman,
Porthcurnow, Sep. 20th. Ass. Soc. T.E.

Notice to Correspondents.

C.D.—Elisha Gray took out a patent on July 29th, 1874, for "improvements in the method of, and apparatus for, transmitting musical tones by electricity." His specification, in his agent's name—Johnson—is No. 2,646. See description under heading "Notes" in this number.

THE TELEGRAPHIC JOURNAL.

Vol. III.—No. 68.

PNEUMATIC TELEGRAPHY.

Pneumatic Telegraphy has become quite an institution of the age. Scarcely a capital in Europe has failed to avail itself of its facilities to complete its telegraphic system. When stations lie together, close and thick, it is manifestly advantageous to connect them by mechanical means, so as to save, by the transport of the actual telegrams themselves, the multiplication of wires, apparatus, and clerks; and especially so when this can be done with a rapidity equal to that of telegraphy itself. Messages cannot be manipulated or written out at a greater rapidity than forty words per minute, so that if it is possible to transport a telegram itself from one place to another in a minute, not only is speed of transmission obtained but all sources of error are eliminated. In fact the average initial delay occupied by messages on the shortest lines is about five minutes, so that tubes which can convey the messages bodily within this limit are economical and beneficial. The essential element of telegraphy is speed of transmission, and it is evident that when currents of air can produce greater despatch than currents of electricity pneumatic tubes are preferable to wires. But apart from the question of speed of transmission tubes are essentially economical in the employment of staff, for their use reduces the number of clerks required to a minimum. But of course there is a limit to their useful employment, and a point is reached when, from telegraphic and economical grounds, wires surpass tubes in efficiency and desirability. The limit of length is about two miles, for at this distance telegrams exceed the five minutes interval allowed for their average transmission. Of course where rapidity is of no consequence this distance can be much exceeded, but, fortunately for the British public, the one criterion which its telegraphists have always endeavoured to attain, especially since the transfer of its telegraphs to the State, has been swiftness of transmission, and it is to swiftness more than to any reduction in price that the marvellous increase of business is due. In five years telegrams in England have inereased from six millions to twenty millions.

The first germ of pneumatic telegraphy was sown in the year 1810, when Mr. George Medhurst (who, because he lived in *Denmark-street*, *Soho*, has always been called a Danish engineer) proposed and patented "a new method of conveying letters and goods with great certainty and rapidity by *air*." His proposal is so clear and interesting that it deserves extracting:—

"If a light and hollow vessel is so formed as to fill the area of a tube, and to move freely through it, carrying papers not exceeding three ounces in weight, it will be driven through the tube with the velocity of 150 feet in a second by the pressure of nine ounces per square inch.

"And therefore a tube of uniform dimensions being laid upon or under ground, from one place to another, without any sudden curvature, will form the means of conveying packets of letters with the velocity of 100 miles per hour, by forcing the air through the tube with a pressure of three ounces per square inch for every ounce weight in motion.

"And if there are two tubes of the same dimensions leading from one place to another, packets of letters may be conveyed each way, at the same time, without a possibility of their clashing against each other; and many packets may be conveyed the same way, in the same tube, which can never approach each other, but will all proceed with an uniform motion and equal rapidity to their destination, where, the tube entering an air-tight room, the packets will be deposited, and may be delivered or forwarded to the next stage through their proper tubes, commencing in the same room, and their progress can never be impeded by the seasons or the elements."—P. 6-7.

This proposal did not take practical form until 1854, when Mr. Latimer Clark laid down a $1\frac{1}{2}$ inch lead pipe between the Electric Telegraph Company's Central Station, Lothbury (LY), and the Stock Exchange. An engine exhausted a receiver at LY, and carriers containing the messages were sucked through from the Stock Exchange. The traffic was only required to flow in one direction. In 1858, the system was extended to Mincing Lane, and about 1860 Mr. Varley introduced the use of compressed air, so that messages were drawn in one direction by a vacuum, and propelled in the other direction by a prenum. Mr. Clark had previously used a vacuum to work in both directions, a receiver at Mincing Lane having been exhausted by the engine at LY, by means of a special pipe laid down in the same trench with the carrier tube.

In 1865 the system was introduced in Paris. Considerable modifications were made in its mode of working. Compressed air was used entirely, and the necessary pressure was obtained by admitting water from the mains into large air reservoirs. This tube served several stations, which were worked intermediately, like a line of railway, or a telegraph current, each station having its own store of power to propel or forward the carrier on to the next place. This mode of ob-

taining power was found wasteful and expensive, and it has been nearly entirely abandoned in favour of steam working at one end of the circuit.

About the same period (1865), a system was introduced in Berlin by Messrs. Siemens, who used two pipes, laid in the same trench, between the Telegraph Station and the Bourse, arranged in a circuit, through which a continuous current of air was always kept flowing in the same direction by a double acting air pump, worked by a steam engine. This last mode of working was tried in London, but it has not proved successful, and it has been abandoned.

It will be seen how closely this system of Siemens' resembles that of Medhurst, and how curiously history works in a circle, for the vision of 1810 has become the stern fact of 1875. In all the places named the pneumatic telegraph has received considerable extension, and it has also been largely introduced in Vienna, where the Parisian system has been adopted.

ON WHEATSTONE'S ELECTRIC TELEGRAPH IN RELATION TO SCIENCE.

(Being an argument in favour of the full recognition of Science as a branch of Education.)

A Lecture delivered at the Royal Institution of Great Britain, on Friday, June 11th, 1858.

By Professor Faraday, D.C.L., F.R.S.*

The development of the application of physical science in modern times has become so large and so essential to the well-being of man that it may justly be used, as illustrating the true character of pure science, as a department of knowledge, and the claims it may have for consideration by governments, universities, and all bodies to whom is confided the fostering care and direction of learning. As a branch of learning, men are beginning to recognize the right of science to its own particular place;—for, though flowing in channels utterly different in their course and end to those of literature, it conduces not less, as a means of instruction, to the discipline of the mind; whilst it ministers, more or less, to the wants, comforts, and proper pleasure, both mental and bodily, of every individual of every class in life. Until of late years, the education for, and recognition of it, by the bodies which may be considered as governing the general course of all education, has been chiefly directed to it only as it could serve professional services,—namely, those which are remunerated by society; but now the fitness of university degrees in science is under consideration, and many are taking a high view of it, as distinguished from literature, and think that it may well be studied for its own sake, *i.e.* as a proper exercise of the human intelligence, able to bring into action and development all the powers of the mind. As a branch of learning, it has (without reference to its applications) become as extensive and varied as literature; and it has this privilege, that it must ever go on increasing. Thus it becomes a duty to foster, direct, and honour it, as literature is so guided and recognized; and the duty is the more imperative, as we find, by the unguided progress of science and the experience it supplies, that of those men who devote themselves to studious education, there are so many whose minds are constitutionally disposed to the studies supplied by it, as there are of others more fitted by inclination and power to pursue literature.

The value of the public recognition of science as a leading branch of education, may be estimated, in a very considerable degree, by observation of the results of the education which it has obtained incidentally from those, who pursuing it, have educated themselves. Though men may be especially fitted by the nature of their minds for the attainment and advance of literature, science, or the fine arts, all these men, and all others, require first to be educated in that which is known in these respective mental paths; and when they go beyond this preliminary teaching, they require a self-education directed (at least in science) to the highest reasoning power of the mind. Any part of pure science may be selected to show how much this private self-teaching has done, and, by that, to aid the present movement in favour of the recognition generally of scientific education in an equal degree with that which is literary; but perhaps electricity, as being the portion which has been left most to its own development, and has produced as its results the most enduring marks on the face of the globe, may be referred to. In 1800, Volta discovered the voltaic pile; giving a source and form of electricity before unknown. It was not an accident, but resulted from his mental self-education: it was at first a feeble instrument, giving feeble results; but by the united mental exertions of other men, who educated themselves through the force of thought and experiment, it has been raised up to such a degree of power as to give us light, and heat, and magnetic and chemical action, in states more exalted than those supplied by any other means.

In 1819, Oersted discovered the magnetism of the electric current and its relation to the magnetic needle; and as an immediate consequence, other men, as Arago and Davy, instructing themselves by the partial laws and action of the bodies concerned, magnetised iron by the current. The results were so feeble at first as to be scarcely visible; but, by the exertion of self-taught men, since then, they have been exalted so highly as to give us magnets of a force unimaginable in former times.

In 1831, the induction of electrical currents one by another, and the evolution from magnets was observed,—at first in results so small and feeble, that it required one much instructed in the pursuit, to perceive and lay hold of them; but these feeble results, taken into the minds of men already partially educated and ever proceeding onwards in their self-education, have so developed, as to supply sources of electricity independent of the voltaic battery or the electric machine, yet having the power of both, combined in a manner and degree which they, neither separate nor together, could ever have given it, and applicable to all the practical electrical purposes of life.

To consider all the departments of electricity

* We have much pleasure in reprinting this just tribute from one great man to another great man.

fully, would be to lose the argument for its fitness in subserving education, in the vastness of its extent; and it will be better to confine the attention to one application, as the electric telegraph, and even to one small part of that application, in the present case. Thoughts of an electric telegraph came over the minds of those who had been instructed in the nature of electricity as soon as the conduction of that power with extreme swiftness through metals was known, and grew as the knowledge of that branch of science increased. The thought, as realized at the present day, includes a wonderful amount of study and development. As the end in view presented itself more and more distinctly, points at first apparently of no consequence to the knowledge of the science generally, rose into an importance which obtained for them the most careful culture and examination, and the almost exclusive exercise of minds whose powers of judgment and reasoning had been raised first by general education, and who, in addition, had acquired the special kind of education which the science in its previous state could give. Numerous and important as the points are which have been already recognised, others are continually coming into sight as the great development proceeds, and with a rapidity such as to make us believe that much as there is known to us, the unknown far exceeds it; and that extensive as is the teaching of method, facts, and law, which can be established at present, an education looking for far greater results should be favoured and directed.

The results already obtained are so large, as even in money value to be of very great importance; —as regards their higher influence upon the human mind, especially when that is considered in respect of cultivation, I trust they are, and ever will be, far greater. No intention exists here of comparing one telegraph with another, or of assigning their respective dates, merits or special uses. Those of Mr. Wheatstone are selected for the visible illustration of a brief argument in favour of a large public recognition of scientific education, because he is a man both of science and practice, and was one of the very earliest in the field, and because certain large steps in the course of his telegraphic life will tell upon the general argument. Without referring to what he had done previously, it may be observed that in 1840 he took out patents for electric telegraphs, which included, amongst other things, the use of the electricity from magnets at the communicator, the dial-face,—the step-by-step motion,—and the electro magnet at the indicator. [At the present time, 1858, he has taken out patents for instruments containing all these points; but these instruments are so altered and varied in character above and beyond the former, that an untaught person could not recognise them.] The changes may be considered as the result of education upon the one mind which has been concerned with them, and are to me strong illustrations of the effects which general scientific education may be expected to produce.*

In the first instruments powerful magnets were used, and keepers with heavy coils associated with them. When magnetic electricity was first discovered, the signs were feeble, and the mind of the student was led to increase the results by increasing the force and size of the instruments. When the object was to obtain a current sufficient to give signals through long circuits, large apparatus were employed, but these involved the inconveniences of inertia and momentum; the keeper was not set in motion at once, nor instantly stopped; and, if connected directly with the reading indices, these circumstances caused an occasional uncertainty of action. Prepared by its previous education, the mind could perceive the disadvantages of these influences, and could proceed to their removal; and now a small magnet is used to send sufficient currents through 12, 20, 50, a hundred, or several hundred miles; a keeper and helix is associated with it, which the hand can easily put in motion; and the currents are not sent out of the indicating instrument to tell their story, until a key is depressed, and thus irregularity contingent upon the first action is removed. A small magnet, ever ready for action and never wasting, can replace the voltaic battery; if powerful agencies be required, the electro-magnet can be employed without any change in principle or telegraphic practice; and as magneto-electric currents have special advantages over voltaic currents, these are in every case retained. These advantages I consider as the results of scientific education, much of it not tutorial, but of self; but there is a special privilege about the science-branch of education, namely, that what is personal in the first instance immediately becomes an addition to the stock of scientific learning, and passes into the hands of the tutor, to be used by him in the education of others, and enable them in turn to educate themselves. How well may the young man entering upon his studies in electricity be taught by what is past to watch for the smallest signs of action, new or old; to nurse them up by any means until they have gained strength; then to study their laws, to eliminate the essential conditions from the non-essential, and at last, to refine again, until the encumbering matter is as much as possible dismissed, and the power left in its highly developed and most exalted state.

The alternations or successions of currents produced by the movement of the keeper at the communicator, pass along the wire to the indicator at a distance; there each one for itself confers a magnetic condition on a piece of soft iron, and renders it attractive or repulsive of small permanent magnets; and these acting in turn on a propelment, cause the index to pass at will from one letter to another on the dial face. The first electro-magnets, *i.e.*, those made by the circulation of an electric current round a piece of soft iron, were weak; they were quickly strengthened, and it was only when they were strong that their laws and actions could be successfully investigated. But now they were required small, yet powerful. Then came the teaching of Ohm's law; and it was only by patient study under such teaching that Wheatstone was able so to refine the little electro-magnets at the indicator that they should be small enough to consist with the fine work there employed, able to do their appointed work when excited in contrary directions by the brief currents flowing from the original common magnet, and unobjectionable in respect of any resistance they might offer to the transit of these tell-tale currents.

* The former and the present apparatus were set to work in illustration of the points as they were noticed.

These small transitory electro-magnets attract and repel certain permanent magnetic needles, and the to-and-fro motion of the latter is communicated by a propelment to the index, being there converted into a step-by-step motion. Here everything is of the finest workmanship; the propelment itself requires to be watched by a lens, if its action is to be observed; the parts never leave hold of each other; the vibratory or rotatory ratchet wheel and the fixed pallets are always touching, and thus allow of no detachment or loose shake; the holes of the axes are jewelled; the moving parts are most carefully balanced, a consequence of which is that agitation of the whole does not disturb the parts, and the telegraph works just as well when it is twisted about in the hands, or placed on board a ship or in a railway carriage, as when fixed immovably. Where it is possible, as in the vibratory needle, the moving parts are brought near to the centre of the motion, that the inertia of the portion to be moved, or the momentum of that to be stopped, should be as small as possible, and thus great quickness of indication obtained. All this delicacy of arrangement and workmanship is introduced advisedly; for the inventor, whom I may call the student here, considers that refined and perfect workmanship is more exact in its action, more unchangeable by time and use, and more enduring in its existence, than that which, being heavier, must be coarser in its workmanship, less regular in its action, and less fitted for the application of force by fine electric currents.

Now there was no chance in the course of these developments;—if there were experiments, they were directed by the previously acquired knowledge;—every part of the investigations was made and guided by the instructed mind. The results being such (and like illustrations might be drawn from other men's telegraphs or from other departments of electrical science), then, if the term education may be understood in so large a sense as to include all that belongs to the improvement of the mind, either by the acquisition of the knowledge of others, or by increase of it through its own exertions, we learn by them what is the kind of education science offers to man. It teaches us to be *neglectful* of nothing; not to despise the small beginnings, for they precede of necessity all great things in the knowledge of science, either pure or applied. It teaches a continual comparison of the *small and great* and that under differences almost approaching the infinite; for the small as often contains the great in principle as the great does the small; and thus the mind becomes comprehensive. It teaches us to deduce principles carefully, to hold them firmly, or to suspend the judgment: to discover and obey *law*, and by it to be bold in applying to the greatest what we know of the smallest. It teaches us first, by tutors and books, to learn that which is already known to others, and then, by the light and methods which belong to science, to learn for ourselves and for others;—so making a fruitful return to man in the future for that which we have obtained from the men of the past. Bacon, in his instruction, tells us that the scientific student ought not to be as the ant who gathers merely, nor as the spider who spins from her own bowels, but rather as the bee, who both gathers and produces.

All this is true of the teaching afforded by any part of physical science. Electricity is often called wonderful—beautiful; but it is so only in common with the other forces of nature. The beauty of electricity, or of any other force, is not that the power is mysterious and unexpected, touching every sense at unawares in turn, but that it is under *law*, and that the taught intellect can even now govern it largely. The human mind is placed above, not beneath it; and it is in such a point of view that the mental education afforded by science is rendered supereminent in dignity, in practical application, and utility; for, by enabling the mind to apply the natural power through law, it conveys the gifts of God to man.

SECONDARY BATTERIES OF M. PLANTE.

By A. NIAUDET-BREGUET.

Secondary currents, or currents of polarisation, have formed the subject of numerous researches ever since the period when they were discovered, that is to say, since the commencement of the present century; but it is only within the last few years that it has been ascertained that they are capable of being applied to purposes of practical utility.

During the last fifteen years M. Gaston Planté has been engaged upon the investigation of this subject, and, by continuous efforts and by successive stages of progress, he has arrived at results of the greatest interest—results of the nature of which we shall now endeavour to give an idea.

The reader knows that the Voltameter is an instrument in which water is decomposed by the current from an ordinary galvanic battery; in fig. 1 is represented one of the fundamental experiments in Physics. At the exact instant when the Voltameter has been just subjected to the action of the battery, it may be regarded as a secondary couple or element; if the two electrodes are now connected with the wire of a galvanometer the needle of the latter will be deflected during several seconds, and will show the passage of a current which grows gradually weaker and becomes imperceptible after a somewhat short space of time. This current is what is called a secondary current; it has been supplied by the battery to the Voltameter, and it is given back again by the latter.

M. Planté showed, as early as 1859, that lead is the most suititable metal for employment in secondary batteries, and he has, since that time, still further confirmed the superiority of this metal. Fig. 2 shows a secondary element as now constructed. In a tall vessel of glass, guttapercha, or ebonite, are placed two sheets of lead, rolled spirally, and parallel one to the other, and kept from touching by two cords of indiarubber rolled up with them; these two sheets of lead are immersed in a solution of one part of sulphuric acid to nine parts of water. The vessel is closed by a sealed cover pierced with a small hole, through which the liquid can be poured in or extracted, and which also allows the escape of any gas which may be generated during the charging of the battery. The apparatus is surmounted by a disc of ebonite, upon which are fixed two contact pieces in connection with the two electrodes; two

clips are also provided for the purpose of holding metallic wires to be made red hot or melted by the secondary current.

Two Bunsen cells or, in their stead, three Daniell cells are required to charge this secondary element. During the operation of charging one of the electrodes oxydizes, a brown coating of peroxide of lead soon shows itself, and the metallic appearance disappears entirely; the other electrode also changes in appearance, its surface becomes covered with a powdery grey coating.

When the charge has attained its maximum, that is to say, when oxygen commences to be given off by the brown electrode, it is well to disconnect the secondary element from the charging battery, for any further expenditure of the polarising current is entirely wasted.

The secondary element once charged in this manner and left to itself will retain a portion of its charge for several days; and even at the end of a week it is still far from being exhausted.

The secondary element, when fully charged, has an electro-motive force equal to one and a half times that of a Bunsen; it will redden a platinum wire of a greater or lesser diameter according to its size, or rather according to the size of the electrodes; for it is of course understood that the quantity of electricity which the apparatus will furnish is in proportion to the extent of leaden surface subjected to the action of the polarising current and covered with an active electro-chemical deposit.

It should be remarked that the particular (spiral) form of the electrodes gives an element having a large surface and a small resistance within a small space, so that one of Plantés secondary elements is equal to an active or ordinary element of a very unusual size; the small pattern has an active surface of 8 square decimetres (124 square inches), the large pattern a surface of 40 square decimetres (620 square inches).

The current furnished by the secondary element will effect chemical decomposition, act upon an electro-magnet, &c.; but if its intensity is measured by any of the ordinary methods, as, for example, by means of a galvanometer, it will be found to decrease gradually from the maximum spoken of above. This diminution is rather slow if the circuit has a large resistance, and if, in consequence, the electricity passes in small quantity; but it is, on the contrary, very rapid if the circuit is one of but small resistance, because the electricity then flows in large quantity.

The period of discharge gives rise to an interesting observation. The battery is to all appearance completely discharged, but if it is allowed to rest for a few minutes with the circuit disconnected, it is found to have reacquired a certain amount of force, and is able again to give forth a certain quantity of electricity. The battery being then discharged of the first *residuum*, and again left to itself for a short time, will give a second *residuum* smaller, indeed, than the first. The latter will not be the last; several other charges can still be obtained.

M. Planté has very clearly explained this peculiarity. The secondary element when it comes into action is discharged, and is at the same time polarized, as in the case of batteries with a single fluid. This polarization acquires after a certain time a power almost equal to that of the weakened secondary element, and the action then ceases or becomes very slight. If the battery is now allowed to rest it depolarizes itself, as happens in the case of all single fluid batteries polarized by their own action; the battery, once depolarized, is then again ready to give forth a current, but in the next discharge it becomes polarized afresh and so on.

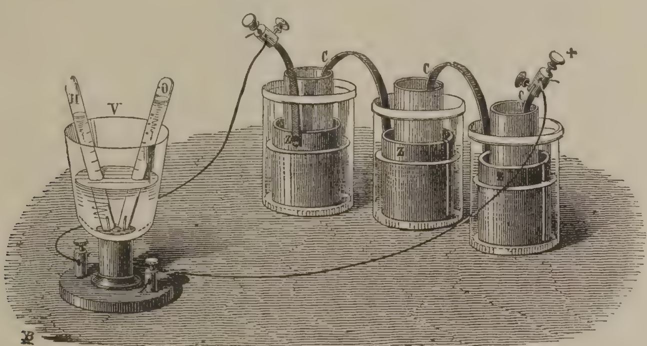

FIG. 1.—*Voltameter and Daniell battery.*

Let us now suppose that the secondary element has been entirely discharged or nearly so, it can be recharged by means of the two Bunsen elements as at first; but it is worthy of notice that a fresh charge is communicated all the more quickly as the operation is performed more promptly after the discharge.

Moreover, a secondary element is all the better for having been charged and discharged a greater number of times; at first, when it is almost new, there is an advantage in polarizing the electrodes, sometimes in one direction and sometimes in the other, reversing several times the direction of the charge; but when the element is formed the greatest care must, on the contrary, be taken to charge it always in the same dlrection. If this precaution is neglected the time required for charging will be much increased, for the oxide of lead which may happen to remain upon one of the electrodes must be reduced and the plate, previously negative, must be oxydized. But after this operation the secondary element regains all its power and may even be said to be all the better for it.

Figure 3 shows a peculiar form in which M. Planté has arranged the secondary element, and to which he has given the name of *Briquet de Saturne* (Saturn's tinder-box). On the upper part of the box may be seen two small clips, between which s stretched a platinum wire; every time that, by pressing with the finger, the two springs at the bottom of the box are brought in contact, the battery sends a current through the platinum wire heating it to redness, the taper is then lighted almost instantaneously. With an apparatus of this kind well charged the taper may be lighted one hundred times, and it is only after being used this large number of times that it is necessary to recharge with three Daniell elements. Thus we have a new means of obtaining fire and a very economical one, for the secondary element itself consumes nothing and the charging battery merely a few grammes of sulphate of copper for supplying the apparatus during a very long period.

The same apparatus might be employed either in civil or military engineering for exploding mines; it has been shown by experiment that with fuses of rather fine platinum wire (one-twentieth of a millimetre in diameter), an explosion can be produced through a copper wire 900 metres in length and three millimetres in diameter.

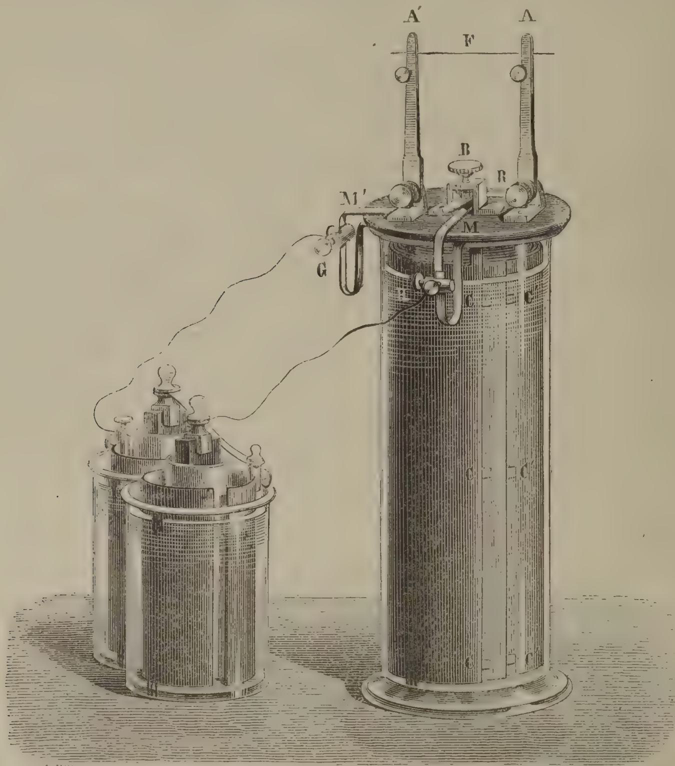

Fig. 2.—*Two Bunsen elements charging a secondary element.*

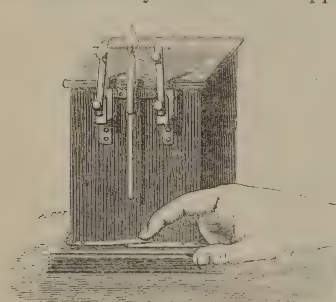

Fig. 3.

With an apparatus of a similar kind, surgeons are enabled to cauterize a wound, and this application has already been often brought into practical use; a secondary element is much more easily carried into an hospital, and especially into the house of a patient, than the active elements which it is capable of replacing.

These secondary elements can be joined together, either for intensity or for quantity, and they form batteries capable of producing all the effects of batteries of the ordinary form, and of the most powerful kind. Figure 4 represents a secondary battery as arranged by M. Planté, and such as would render the most valuable service in a variety of applications.

The number and size of the couples require to be varied, in order to obtain given effects of tension and quantity. Here, we have twenty elements arranged in two rows; at the upper part is an ingeniously contrived commutator, so arranged that in one position it joins all the elements together for quantity, and in another, at right angles with the first, it groups them for intensity. In the first

position all the outer electrodes are joined to one metallic bar, and all the inner electrodes to another similar bar, so that the whole apparatus is equivalent to a single element of very large surface; it is whilst in this position that the secondary battery is charged; two Bunsen elements are sufficient to effect a complete charge, the time occupied being longer or shorter according to the size of the charging cells and the extent of the leaden surface to be polarized. In the second position of the commutator, the exterior electrode of each element is connected to the interior electrode of the next element, and the apparatus becomes a real battery of twenty cells; it is whilst connected in this manner that the battery is discharged; the power at the beginning of the discharge is equal to thirty Bunsen elements of very large surface.

As the discharge proceeds, the tension falls, as we have explained when speaking of the single secondary element. If one minute has been the time occupied in charging the secondary battery, in quantity, from the two Bunsen elements, it cannot be expected that the discharge, in intensity, will produce the effect of thirty Bunsen elements of the same size during more than four seconds, for the apparatus does not produce electricity, and can only transform that which is imparted to it. M. Planté has made exact experiments upon this point, and has found that in the transformation about one-tenth part is lost, or, in other terms, that the apparatus gives back nine-tenths of what has been expended.

It is easily perceived that the secondary battery can only produce effects of short duration, but in a very great number of cases such effects are all that is required.

If, for example, it is desired to explode simultaneously a large number of mines by means of fuses of fine wire, the object can be attained by joining all the fuses as branches out of a single wire, and discharging a secondary battery into all of them simultaneously. This plan is a very economical one; there is no doubt that it involves much less labour and cost to set up two Bunsen elements and charge the secondary battery than to charge the twenty or thirty Bunsen elements whose place is supplied; it being of course understood that the work is required from the battery during but a few seconds, and that the operation is repeated but four or five times in the course of the day. Moreover, the secondary battery can be easily carried about to the different workshops where the works extend over a considerable area, as during the construction of a long tunnel or the sinking of shafts for mines.

In small laboratories the expense of setting up a large Bunsen battery is an obstacle to the carrying out of certain experiments, either for demonstration to pupils or for the investigations and researches of the teacher. The greater number of these experiments become possible by the use of the Planté battery. If, finally, this apparatus is used in combination with a Gramme machine instead of an ordinary battery, all handling of acids is got rid of as well as all other expense except the purchase of the apparatus, which will last an indefinite time.

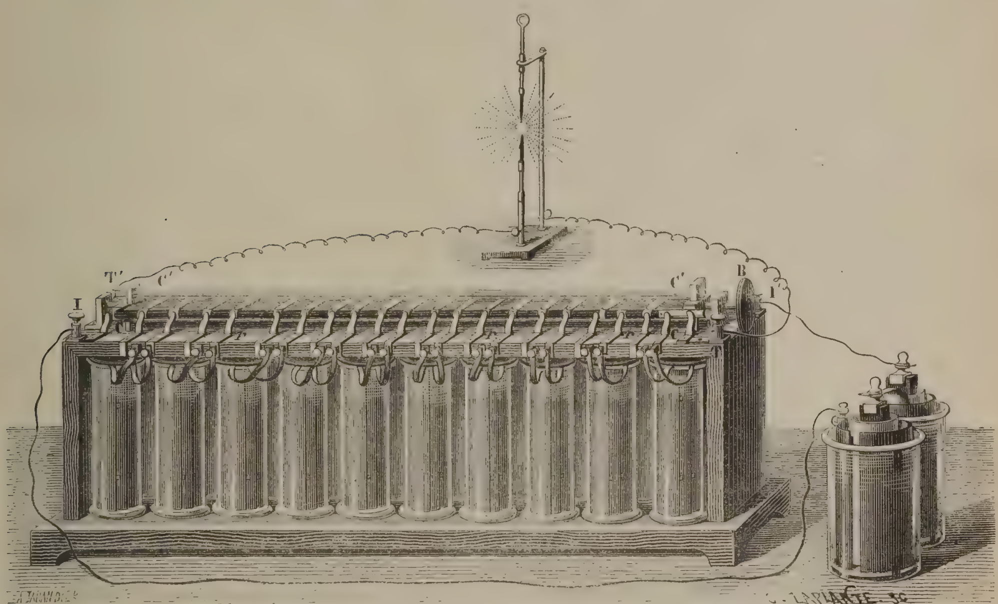

FIG. 4.—*Secondary Battery of twenty elements capable of being charged with two Bunsen elements when arranged for quantity, and producing light upon being discharged with intensity connections.*

We have the greatest confidence in the future of this combined employment of the secondary battery and the Gramme machine, and we shall show in conclusion how it furnishes a solution to the important problem of lighting ships with a view to the avoidance of collisions at sea.

It is not by any means necessary to exhibit at the top of the mainmast a permanent electro light; it will he enough to secure a vessel from collision if it gives warning of its presence around the horizon by a signal of two seconds duration shown once a

minute. Now an unintermittent light of this kind can be produced by a secondary battery alternately charged and discharged; charged from a Gramme machine during fifty-eight seconds and discharged during the remaining two seconds. Upon steamers, which it is specialiy necessary should be well lighted, the engines will work the Gramme machine and the electric light will, as a fact, have its origin in the fuel which heats the boilers. Upon large sailing vessels an electric light would also be found useful, at least on foggy nights. In order to produce it, all that is necessary is to add to the arrangement of which we have spoken an apparatus, by means of which a sailor working alternately two pedals would turn a Gramme machine, and thus produce the exciting current for the secondary battery.

In both cases the movement of the commutator of the battery could be effected automatically after the completion of the number of revolutions of the Gramme machine required to charge the battery, and a second time after the number of revolutions corresponding to the duration of the effective discharge. In this way the flashes and intervals of darkness would be self-produced without any personal intervention or supervision.

It will be observed that this system of intermittent lighting would permit the arrangement of certain useful combinations; for example, the Transatlantic Company might adopt a flash of two seconds every minute, the Cunard Company another variation, such as a flash of one second every quarter minute, the Peninsular and Oriental Company, a different combination, &c., &c. The result would be that any one coming within the horizon of these vessels would know to which Company they belonged, and would be able, in case of necesstity, to furnish useful information. With a system of this kind it would be easier to know the character of a ship by night than by day. A ship in distress should signal by a peculiar arrangement of flashes, to be adopted by vessels of all nations, and to be understood by all; such a signal would be more distinct than the firing of guns or blowing of whistles, which are often rendered inaudible by the noise of the storm. Lastly, in the case of a squadron sailing in company, the flashes could be used to transmit the orders of the chief commander to the commanders of the other vessels; the alphabets at present in use could be easily transformed and adapted to this new means of communication.

We may add that the proposed combination is applicable to the transmission of signals between different points in a besieged place, or of large entrenched camps such as it is proposed to establish for the defence of the French territory; it would also enable those besieged to communicate with very distant points not occupied by the enemy.

Notes.

THE annual soirée of the President of the Society of Telegraph Engineers has been definitely fixed for Tuesday, the 21st December. It will be held at Willis' Rooms. The election of president and officers of the society will take place at the annual general meeting, to be held on Wednesday, the 8th December.

The German Union and the Dunkirk-Denmark cables are interrupted.

Many officers of the old Electric Telegraph Company will learn with regret that Mr. George Cox was buried in Putney on November 17th. He was for many years Superintendent of the South-Western District of that Company, and resided at Southampton. He retired from the telegraph service in 1856. Mr. W. H. Evans, also for many years Superintendent of the Scotch District, died at Oswestry on the 8th inst.

Telegrahic communication by the cable between Penzance and the Scilly Islands is interrupted. During the interruption telegrams for the Scilly Islands will be forwarded to their destination by post from Penzance.

Telegraphic communication between Pernambuco and Para is also interrupted.

The Eastern Company's repairing steamer, the *Chiltern*, left on the 20th for Suez and the Red Sea to repair their broken cable. The repairs, it is expected, will not be completed before Christmas time.

The *Agnes* is now engaged repairing the Madras-Penang cable, whilst the *Hawk* is about to effect some necessary repairs to the Lisbon cable. The *Caroline* is at work on the Dunkirk-Denmark cable, which is interrupted.

M. Planté has shown that a cloud of metallic matter detached from the electrode by a current of high potential in a liquid, assumes a gyratory movement when acted on by a magnet, and he suggests that the form of spiral nebulæ observed in the heavens may thus be due to strongly magnetic celestial bodies in their neighbourhood.

We learn that a professorship for the special teaching of telegraphy, both theoretical and practical, has just been established at the Polytechnic School in Dresden, and that Doctor and Professor K. Edward Zetzsche, who is well known to our readers as a contributor to this Journal, and the author of numerous publications upon telegraphy, has had the honour to be appointed to fill it. If, as there is reason to expect, this special teaching is attended with the success which the extension and importance of telegraphy ought to assure for it, there will probably arise the question of completing the plan by the subsequent formation, in this institution for higher education, of an independent section for the study of telegraphy under conditions similar to those which already exist for

the other branches of engineering. We cannot but wish the greatest success to an institution which comes forward to supply a deficiency, which has been for a long time felt, in higher education.—(*Journal Telegraphique.*)

M. Jules Sommati, of the the Italian Telegraph Administration, has proposed a new form of electro-magnet. He describes his invention in the following words :—" The molecular currents of the " soft iron of electro-magnets in a state of rest " have different directions, whose resultant is zero. " The passage of an electric current has the effect " of giving to these molecular currents a magnetic " direction. On the other hand, the numerous " experiments made by M. de Haldat have led " that physicist to the conclusion that the mag- " netization in electro-magnets is entirely super- " ficial. If, then, the number of molecules upon " which the current acts is increased, that is to " say, the lateral surface of the soft iron (other " conditions remaining the same), an augmenta- " tion of magnetic power will be obtained. Con- " sequently, with equal bulk, the form which gives " the greatest amount of lateral surface will be " the best for the cores of the electro-magnet. " Now, as a prism, whose section is an equilateral " triangle, is that form which gives the greatest " amount of lateral surface, there will be a real " advantage in substituting this prismatic form " for the cylindrical form whose lateral surface is " to that of a prism as 1 to 1·287, or nearly as 10 " to 13." M. Sommati has made and tried two electro magnets (equal in size and length, and surrounded by an equal number of convolutions of silk-covered copper wire), the cores of one being cylindrical, and those of the other prisms having their sections equilateral triangles, the edges being slightly rounded. The magnetic power of these two electro-magnets, measured by a balance on the Becquerel system, gave a very sppreciable difference in favour of the latter, the advantage being almost proportional to the surfaces of the cores.—(*Journal Telegraphique.*)

The following extracts are taken from the annual report of the Hon. W. Orton, President of the Western Union Telegraph Company :—

" The gross receipts for the year from all sources, except proceeds of bonds, were 9,564,574.60 dols. ; the gross expenses were 6,335,414.77 dols. ; the difference 3,229,159.83 dols. being net profit. All sums paid as rental for leased lines are included in the gross expenses.

" Compared with the preceding fiscal year, there was an increase in the gross receipts of 301,920.62 dols. ; a decrease in the expenses of 420,319.06 dols. ; and increase in the net profit of 722,239.68 dols.

" There were in operation at the end of the year 72.833 miles of line, 179,294 miles of wire, and 6,565 offices.

" The number of messages transmitted during the year was 17,153,710, being an increase of 824,454 over the preceding year.

" The Punta Rassa cable, which had been interrupted several times during the summer, involving a considerable loss of revenue, and extra expenses for temporary repairs, gave out entirely a few weeks ago, since when communication has been maintained by steamer. While this is being written, information has been received that the *Morse* has successfully laid the new cable, which is working perfectly, and that telegraphic communication with Key West and Havana has been restored.

" A fault has been discovered in the cable o 1869, between Key West and Havana, and although the use of this cable is not required for the present volume of traffic, the new and better cable of 1873 being capable of passing double the present number of messages, the *Morse* will proceed at once to discover and repair the fault. When this has been done, the other cable between Key West and Punta Rassa will be repaired, and when this is done the company will then have two lines of cable from Punta Rassa to Havana.

" The growth of the company's property and business during the nine years which have passed since the consolidation with the other principal telegraph lines is shown by the following statistics :— From 1867 to 1875 the extent of line has increased from 46,270 to 72,833 miles, and the wires from 85,290 to 179,294 miles, being an increase of 57 per cent. of line, and 110 per cent. of wire. The number of offices and stations has increased from 2,565 to 6,565, equal to 156 per cent. During the same time the number of messages transmitted has increased 192 per cent., the rate of tolls has decreased 51 per cent., and the gross receipts have increased 46 per cent. The average cost per message, during the same time, has been reduced from 67 to 37 cents. or about 45 per cent. The increase of 192 per cent. in the number of messages transmitted annually, while the mileage of wire has increased but 110 per cent., is explained by the fact that the number of messages transmitted per mile of wire has been increased 41 per cent.

" The ability to make so large an increase in the carrying capacity of the wires, is due in part to improvement in their conductivity and insulation, and in part to the introduction of the duplex and

quadruplex apparatus, by means of which one wire is made to do the ordinary work of two, three, or four wires. By means of this apparatus, during the past year, the company has had the use of more than 30,000 miles of what may be called 'phantom wire,' which has cost nothing to provide, repair, and maintain except the cost of the new apparatus, which is but little more expensive than that in general use, and is adapted to all ordinary purposes The cable steamer *Professor Morse* successfully completed the laying of the new cable of the International Ocean Telegraph Company between Key West and Punta Rassa on the 11th ult. Mr. Theophilus Smith, assistant to Sir Samuel Canning, the engineer employed to superintend the construction and laying of the cable, had charge of the work. The insulation of the new cable is excellent, tests showing a resistance of 360 megohms per knot."

The old Punta Rasa cable which had been interrupted as reported above, was successfully repairing. During the repairs, however, the pressure of "cable borers" was discovered.

The reports of the Italian Telegraph Service show that its development has very largely increased since 1861, when the present constitution of the empire was established. The following extracted statistical table of comparison will briefly show the increase :—

	1861. miles.	1873. miles.
Length of lines	4,971 ..	13,670
Length of wires	8,078 ..	43,497
Number of offices	225 ..	1,622
Number of instruments ..	400 ..	2,800
Government messages per annum	180,000 ..	300,000
Private messages per annm	600,000 ..	5,040,000

The Post Office announces the following,—

Information has been received from the Eastern Telegraph Company that telegrams for the undermentioned places in Peru can now be prepaid to their destination. The rates to be collected are (1) the rate to Valparaiso, £13 7s. 6d, for 20 words, or less, to which must be added (2) the following rates:—

	10 Words. £ s. d.		Each additional word. £ s. d.
Iquique - -	2 10 0	—	0 5 0
Arica - - -	3 15 0	—	0 7 6
Islay & Mollinde	5 0 0	—	0 15 0

The following circular has been issued by the Direct United States Cable Company (Limited):

Palmerston Buildings, Old Broad Street,
London, E.C., Nov. 17.

Sir,—I am desired by the Board to inform you that the company's Ireland and Novia Scotia cable was repaired on the 5th of this month, and reopened for public traffic on the following day. Since that time our cables have been in excellent working order, and have been transmitting a fair share of Transatlantic telegrams. Before this interruption both cables were tested by me in Ireland, and I found the insulation perfect and the inductive capacity so low as to make a very high speed of transmission possible, whilst the conductivity exceeded my most favourable expectations. On the completion of my tests the contractors had our cables tested on their behalf by the eminent electrician, Sir William Thomson. From his very full report of his various and exhaustive tests, I quote the following passage:— "In conclusion, I am glad to be able to say that my tests proved the cable to be in perfect condition as to insulation, and showed its electrostatic capacity and copper resistance to be so small as to give it a power of transmitting messages, which, for a Transatlantic Cable of so great a length, is a very remarkable as well as valuable achievement." In addition to the favourable conclusion established by these tests, I may state that the specimens of the cable which have been picked up after a submersion of more than nine months from a depth of 2,240 fathoms, show the cable to be as perfect and as strong in every respect as it was when it left the works of the contractors. This company's cables are thus not only electrically, but also mechanically in the most perfect condition, and now possess in all respects the same high standard that they had previous to the late interruption. The expectations of this company that a great efficiency would be obtained in transmitting messages have been fully realised, as more than once telegrams handed in at the London office of this company were delivered to the addresses at New York within four minutes of the time of their receipt. The traffic, which may be said to be only now developing, has made a very satisfactory beginning. Customers are daily increasing, and in a few days this company will open an office in Liverpool for Transatlantic messages, which will be sent direct over a special wire to Ireland to their ultimate destinations. Looking at the interest which you naturally take in the prosperity of this company, I venture to ask you, not only to send your own messages to America over this company's cables, but also, if possible, to obtain the custom of your friends. A decided advantage offered by this company consists in the line being worked between London, Liverpool, and New York by this Company's own staff, thus insuring perfect uniformity in the mode of working, and in the maintenance of discipline in all the company's

stations, and thereby eliminating all the inconveniences of handing over messages between those places from one administration to another.—I am, sir, your obedient servant,

G. von Chauvin, Managing Director.

Proceedings of Societies.

THE SOCIETY OF TELEGRAPH ENGINEERS.

An ordinary general meeting was held on Wednesday, the 24th November, Professor Abel, F.R.S., Vice-President, in the chair.

After the ordinary business eleven new candidates were proposed.

The adjourned discussion on the "Durability of Guttapercha and Indiarubber Joints" was resumed by Mr. Warren, who spoke of the care required in making Indiarubber joints.

Messrs. Bell and Preece entered into descriptions of the new paraffin joint for street work, which, although not successful up to the present time, had, by the nature of the defects, given sufficient indication that the removal of those defects would result in a valuable joint for the future. The joint is ordinarily made by passing the guttapercha wires through two holes bored in a small oval-shaped piece of wood, the ends of the copper wire are then twisted and soldered; over this is placed a zinc tube, which fits the wooden base, into this melted paraffin is poured and the joint is complete. Joints made eighteen months ago still tested perfect.

The discussion was continued and a description given by Captain McEvoy of the mechanical joint used for torpedo cables.

The discussion was concluded with a vote of thanks to Mr. Henry Mance, the author.

A paper was then read, of which the following is an abstract:—

Experiments conducted for the purpose of ascertaining whether the teredo borer prefers guttapercha to indiarubber.—*By* Henry Mance.

Having received instructions in 1874 to submerge some pieces of cable in the Kurrachee Harbour to ascertain, if possible, whether indiarubber was as liable to the attacks of borers as guttapercha, the following experiments were made by me for the purpose of obtaining the desired information.

The pieces laid in the harbour for trial were as follows:—

1 length of bare guttapercha core.
1 length of bare indiarubber core.
1 length of Persian Gulf guttapercha cable.
1 length of Persian Gulf indiarubber cable.

One of the sheathing-wires had been removed throughout from each of the pieces of cable. The length of each piece was nearly 200 yards, and they all tested good before submersion. They were laid in the immediate vicinity of each other, and, to make the conditions of trial as equal as possible, the bare percha core was lashed alongside the piece of guttapercha cable; the bare indiarubber core was also lashed to the indiarubber cable.

On recovery after a submersion of nearly ten months, the only piece which tested good was the length of indiarubber cable; the other three were bad from the following causes:—

The core of the guttapercha cable was riddled by borers, the conductor being exposed in most cases; there were probably a hundred perforations in this piece.

The length of bare guttapercha core laid alongside the foregoing piece had but *five* borer holes in it; it was otherwise uninjured, as the barnacles grow *round* guttapercha core, adapting themselves to the form of the core without cutting into it to any dangerous extent.

The piece of bare indiarubber core had not a single borer perforation, but was found to contain a number of very remarkable faults towards the end which had rested in shallow water. The rubber was notched as neatly and regularly as if the injury had been done with a sharp knife, but in a few instances the piece of indiarubber was found remaining in the notch. the conductor being in nearly every case exposed. In the neighbourhood of these faults the core was thickly covered with barnacles, and it is possible that these peculiar injuries have been caused by some marine animal feeding on the barnacles which attach themselves to the core. The barnacles adhere so tightly to indiarubber that it would be difficult for a marine animal to remove them without tearing away a portion of the rubber.

Bare indiarubber core is more susceptible to injury from barnacles than bare guttapercha. As the barnacle grows the base of the shell cuts into the yielding rubber, a second shell attaches itself to the side of the first, the growth of the circumference proceeds towards the conductor, and eventually the sharp edge of one of the cluster reaches the copper wire.

The piece of indiarubber cable tested perfect; but on examination, after stripping off the guards, about a dozen marks were discovered, showing that the borers had been at work. In no case, however, had the teredo succeeded in penetrating to the conductor.

The paper was followed by a second on a similar subject, "Cable-Borers," by Mr. G. E. Preece. This paper gave an interesting account of the ravages of the "Limnoria terebrans," an abstract of which will appear in our next.

The Chairman announced that at the next meeting, on the 8th December, the Election of President and Officers would take place.

The following candidates were balloted for at the end of the meeting, and declared unanimously elected:—

As Foreign Members—Dr. Fr. Dehms, of the Imperial German Telegraphs, Berlin; Frederick Carl Nielson, Great Northern Telegraph Company, Hong Kong; Carl C. Sonne, ditto.

As Members—George Bird, New Zealand Telegraph Department, Canterbury; Captain F. W. Heneage, R.E., Chatham; Lieut. H. P. Nicholls, R.E., ditto; Lieut. Herbert Rawson, R.E., ditto; Lieut. E. F. Rhodes, R.E., ditto; Sir David Salomons, Bart., Tunbridge Wells; William J. Wilson, F.C.S., Royal School of Mines, South Kensington.

As Associates—Edward Applegarth, Palmerston-buildings; Frantz Jacob, Charlton; William

F. Nosworthy, Western and Brazilian Telegraph Company, Monte Video; Alfred Peters, Western and Brazilian Telegraph Company, Bahia; Wm. Donald Smallpiece, Basingstoke.

ON A CURIOUS CASE OF MAGNETIZATION.

By M. J. JAMIN.

(From the *Comptes Rendus* of the Academy of Sciences, Paris.)

I AM indebted to the courtesy of M. Bertrand for becoming acquainted with a curious cause of Magnetization, observed by Galileo, and described by him in a letter addressed, in 1607, to Curzio Picehena. The letter refers to a very extraordinary loadstone.

"It was so powerful, that on presenting the "point of a scimiter at a distance equal to the "thickness of a silver piaster, it could not be held "back, and even a strong man, pressing the scimi- "ter against his chest could not resist the attrac- "tion. I have discovered in this loadstone another "extraordinary effect which I have never met "with in any other magnet: the same pole both "attracts and repels the same piece of iron. At a "distance of at least four or five inches it attracts "the piece of iron, but at a distance of one inch it "repels it. If the piece of iron is placed upon a "table and the magnet is brought very near it, the "iron is repelled and recedes before the magnet if "the latter is pushed forward; but if the magnet "is drawn back immediately, the distance becomes "four inches, the piece of iron is attracted and fol- "lows the magnet as the latter is drawn away; it "never, however, approaches nearer than one inch."

The stone was purchased by the Grand Duke. Galileo was able to examine it at leisure, and the result of his subsequent experiments proved that the piece of iron previously mentioned was magnetized steel, for the stone attracted soft iron at all distances and raised six pounds weight of the latter. Finally, it had the property of attracting at a distance, and repelling when near the same pole of a bar of steel. The stone was unfortuuately lost.

In the course of my investigations, I have come across (without seeking it) a case of magnetization of the same kind, in which there is no kind of mystery.

I will first of all remark that a bar of steel may be magnetized to saturation by a very powerful current, and to one of the halves may be given a southern magnetization, which I shall call *positive*, and which extends to the very centre or heart of the bar. This being done, I submit the bar to a current in the reverse direction, weak at first, but gradually increasing, which produces a northern or *negative* magnetization, limited at first to the surface but penetrating afterwards to an increasing depth, always leaving, however, layers of positive polarity underneath. The effect observed is but the result of the difference of action of the two magnetizations superposed one over the other, as manifested externally. It is first positive, then neutral, and finally negative. I stop directly the change of sign is apparent.

I afterwards dissolve the steel in acid, and it is evident that I thus remove, little by little, the exterior northern or negative layers, and expose the underlying southern ones; that the magnetization observed is at first negative, then diminishes, becomes neutral, and then changes the sign. These results have been already communicated to the Academy.

I have now to add that the southern layers are not laid bare throughout at the same time. They commence to show themselves at the end, and especially at the edges and corners as points, very sharp, and of very small extent. They have then a great tension, but their magnetic momentum is small, because they occupy a very small surface. At the same time there exists a northern layer extending uninterruptedly from the end to the mean line; this is the remainder of the exterior layers which have not yet been eaten away by the acid. The intensity of the latter is almost nil at any given point, but the surface being large the quantity and momentum of this northern magnetism are considerable, more considerable than the quantity and momentum of the southern points which protrude at the very end; it follows that this half of the bar turns to the south as if these last-mentioned points did not exist.

Let us bring forward gradually the southern pole of an ordinary magnet; whilst it is at some distance, it is subject to the predominant influence of the northern layers of our bar, and is attracted, but if it is brought to the end of the bar, it comes very near to the southern points, which are situated at the end, the force of the latter prevails, and repulsion takes place; thus we have attraction at a distance and repulsion upon contact, exactly as in the case of the loadstone of Galileo; and, what is no less curious, upon contact, repulsion of the extremities which turn to the contrary poles of the earth, and attraction of the extremities which turn to the same side. At a sufficient distance, the direction of the effects changes, and everything takes place in the accustomed order.

APPLICATION OF ELECTRO-MAGNETISM TO RAILWAY WHEELS.

By M. DREYFUS.

ATTEMPTS have been made, during a considerable period, to utilise electro-magnetism in working railways; sometimes directly as motor force, sometimes for brakes, sometimes to increase the pressure of the wheels of locomotives against the rails.

Amberger first* employed electro-magnetism thus as motive force in 1851. In 1865, Bellet and De Rouvre showed to the Sociéte des Ingenieurs Civils a model locomotive, meant specially for postal service, but they had also in view the application of their system to trains. In such cases it is a question of whether zinc or coal is dearer, as fuel.

Amberger also proposed, in 1851, the employment of electro-magnetism for brakes; flat electro-magnets should be made to act, at a given moment, on the rails. This would effect a great saving of wheel-tires, the friction and wearing being on the rails; but the method was never thoroughly tried. The first serious experiment with an electro-magnetic brake was made by M. Achard, who is still continuing his observations, and hopes to bring them to a successful issue.

* This is incorrect; for in 1842 an electro-magnetic locomotive, invented by Davison, was tried on the Edinburgh and Glasgow Railway, and in 1838 Coombs brought over a model of an electro-magnetic locomotive from America.

Increase of the pressure of a locomotive's wheels against the rails would favour the action of friction (the mean co-efficient of friction 0·17, sometimes fully under 0·1); and the drawing power of the locomotive cannot, of course, exceed the friction of the wheels on the rails. An increase of the traction force can be obtained by increasing the weight of the locomotive; but such an increase of dead weight is especially disadvantageous on inclines, and the more so that the weight of the locomotive must be calculated according to the greatest incline present on the line. It has often been attempted, therefore, to help the friction with electro-magnetism, but hitherto without any satisfactory success. A new arrangement for this purpose by a Swiss engineer, M. Burgin, has lately been tried on the North-Eastern Railway, in Switzerland. After a brief historic survey we shall describe it.

The first idea of applying electro-magnetism in this way may have been given by a lecture experiment of Professor Eisenlohr, in Carlsruhe, who made a magnet of a horse-shoe-formed locomotive axle, by winding round it 500 m. copper wire, of 4·5 mm. thickness, so that, when the wire was traversed by a current from twenty Grove elements, the magnet would bear 5000 k. In 1846 Dr. Wright proposed to make the wheels of locomotives magnetic, and estimated that each wheel might thus acquire an attractive force of 1000 k. on the rails; he also remarked that the force of attraction might be rendered variable. There is no record of the proposal having been carried out. When M. Niklés was consulted, in 1851, by MM. Amberger and Cassal, as to a physical means of increasing the pressure of locomotive wheels, he recommended electro-magnetism. In his first arrangement, a horse-shoe electro-magnet was fixed to the body of the locomotive, between two pairs of wheels, its poles were about 4 mm. from the rails. A small model acted well on an incline; the motive force was derived from a weight connected with the axle by a cord passing over a pulley at the top of the incline, another weight was suspended from a cord passing to the locomotive over a pulley at the bottom. Soon after, M. Niklés replaced this electro-magnet by coils enclosing the lower part of each wheel nearly to the rail, each coil 250 m. of copper wire; they were attached to the frame of the locomotive. Good results were had thus with a small model on a changeable incline. Thereafter, similar experiments were made on a 20 per cent. incline, with a pair of locomotive wheels 1·10 m. diameter, and with sixteen battery elements; in dry weather the friction was about 350 k.; the adhesion through electro-magnetism 450 k. (or, supposing the co-efficient of adhesion 0·1, 4500 k.); in damp weather the friction went down to 100, while the electro-magnetic adhesion was weakened only about 50 k. A thick layer of tallow on the wheels brought down the magnetic adhesion to 400 k. The magnetic adhesion, therefore, for each pair of wheels might be estimated at about 1000 k. The expenditure in acid and zinc during ten hours' uninterrupted service was about 11·2 gr. It was thought deducible from the experiments that the velocity of rotation of the wheels did not compromise the magnetic action, but from experiments on the Paris and Lyons Railway the opposite was proved; for in the heavy train, which moved with slow velocity up an incline of 10 in 1,000, scarcely 9 per cent. increase in adhesion was gained. Niklés and Amberger, therefore, gave over magnetising the wheels with such coils.

The cause of non-success of M. Niklés' first arrangement lay in the distance of the magnet from its armature; in his second it lay in the fact that the position of the pole could not shift with sufficient rapidity. During the experiments on the Lyons Railway, M. Niklés thought of magnetising the whole circumference of the wheel, and devised a special arrangement for this purpose; which, however, was never carried into practice.

In 1859 Mr. Gerrel, in America, magnetised the lower part of wheels by an arrangement similar to that of M. Niklés. Each coil contained 823 m. copper wire, No. 8, in 288 windings; the battery consisted of 16 Grove elements, and had a zinc surface of about 1935 sq. c. The steam pressure could be raised 8·6 k. without the wheels slipping on the very smooth rails, but to 15·9 k. if the wheels were magnetised; with good rails even to 22·7 k. and 40 k. Similar experiments were made by M. Black, in 1859.

In 1865 a new arrangement was tried on the Central Railway, in New Jersey. The copper coils, fixed round the tires, on the inside of the wheels, made the two wheels on one axle poles of a single magnet. The experiments, continued more than a year, gave an increase of about 40 per cent. in adhesion. These American experiments were discontinued, because at that time it was not understood how to produce, with a dynamo-electric machine, and comparatively small expenditure of mechanism, very powerful electric currents.

In M. Bürgin's system, the entire axle with its wheels is also turned into a magnet with fixed poles. But he envelops the axle itself with the wire; and with increasing thickness of windings towards the wheels, in locomotives that have external cranks, but with uniform thickness in those with internal. In the case of coupled wheels, the winding is so arranged that there is an alternation of poles, the piece of rail between two wheels forming a closed armature. This mode of winding allows an increase of the number of turns, and, consequently, stronger magnetisation. A small locomotive model (but without engine and boiler), with three pairs of wheels, and external cranks, was placed on a 30 per cent. inclined plane, and the coils were connected by long wires and a commutator with five Bunsen elements. The driving force was supplied by a weight of 12 k., the cord of which passed round the three axles. The wheels of the model (its weight was 8·5 k.) slipped in position, if the weight was allowed to run, and the circuit not closed; hut when the current flowed, the model went up the incline. If the brake of the model was applied, the latter remained in position on the plane while the current was flowing; but on interrupting the circuit, the wheels began to slip on the rails, and the model slid down with increasing speed; when the current was admitted again the model stopped, notwithstanding its acquired velocity. On a plane of 100 per cent. incline, the locomotive could be held fixed only when the current was flowing and the brake applied. On the under side of a horizontal line the model was held by magnetic attraction, moved to and fro, and could even be loaded with 7 k.; the entire attraction was thus 15·5 k. On the

horizontal line, still loaded with 15·5 k., it was moved, with brake applied, by a weight (suspended over pulley) of 7·5 k. The coefficient, of friction was thus:—$F_1 = 7·5 : 24 = 0·312$. After removal of the 15·5 k. load, and application of the brake, the model was first moved by 10 k. The coefficient of friction was thus.—$F_2 = 10 : 24 = 0·416$. The proportion of the two was $F_1 : F_2 = 312 : 416$, and even with wet rails, it continued the same.—(*Iron*).

A NEW RELATION BETWEEN ELECTRICITY AND LIGHT: DIELECTRIFIED MEDIA BIREFRINGENT.*

By JOHN KERR, LL.D., Mathematical Lecturer of the Free Church Training College, Glasgow.

(From the *Philosophical Magazine.*)

THE thought which led me to the following inquiry was briefly this:—That if a transparent and optically isotropic insulator were subjected properly to intense electrostatic force, it should act no longer as an isotropic body upon light sent through it. Faraday was often occupied with expectations of this kind; and he has mentioned in his memoir on the Magnetization of Light, and elsewhere in his "Researches," how he experimented in this very direction, upon electrolytes as well as dielectrics, at different times and in many ways, but always without success†. As far as I remember, I have not read or heard of an attempt in this field by any other naturalist. I proceed to offer a few notes of some recent experiments of my own. The investigation is not so complete as I should wish it to be; but it has been carried forward as far as my limited time and means would allow. At present I confine myself to solid dielectrics, reserving the case of liquids for a second paper. The principal results given in this first paper are stated apart, in articles 11, 17, 23.

1. *Dielectric of Plate Glass.*—A piece of good plate glass, ¾ inch thick, is formed roughly, before it leaves the shop, into a rectangular block 6 inches long and 2 wide. In this and subsequent operations, the original polish of the plate is carefully preserved. Two holes, about $\frac{1}{10}$ inch wide, are drilled into the block from its opposite ends; they lie exactly as in continuation of each other, in a line parallel to the longest edges of the block, and midway between opposite faces; and they terminate in well-rounded bottoms at the centre of the block, with a short extent (a quarter inch or less) of clear glass between them. Two fine pillars of glass rise from a stand on the table, distant an inch or two from each other. The block is placed across the pillars (at about a foot from the table), its plate-faces vertical, and the line of borings horizontal; and in this position it is tied securely to the pillars by coils of silk thread. Two thick wires of copper, sheathed in guttapercha, have their bare extremities inserted in the borings, down to the ends. As a provision against the strongest electric action applied in any case, these wires are coated very deeply with lac or sealing-wax at their junction with the glass, and an inch or more outwards. The whole surface of pillars and block is well varnished with lac—except a small space which is left clean upon each of the plate-faces, to allow distinct vision through the centre of the block.

When the dielectric has been thus prepared, its transparency is all that can be desired. Objects bright or faint are seen horizontally through the central parts of the plates (between and around the ends of the borings) quite as well as through a fine window.

2. The electricity is obtained from a Ruhmkorft's induction-apparatus, which gives a spark of 20 to 25 centimetres. The dielectric just described stands upon the table close to the inductorium. The outer ends of the wires from the dielectric are screwed into the knobs of the secondary coil. From the same knob two wires are led to the other side of the instrument, and are connected with two insulated metallic balls, which act as spark-terminals. The distance of these balls, or the actual spark-length in air, is under the observer's control at every instant.

The ends of the secondary coil are separated thus at one place by so many inches of air, and at another place by a quarter inch of glass. When the primary circuit is closed in the usual way, through the oscillating rheotome of the instrument, the air between the spark-terminals is broken by a sensibly incessant discharge, while the glass between the induction-terminals is traversed by a strong electric force. By simple increase or diminution of the distance between the spark-terminals, the intensity of electric strain thus produced at the centre of the glass block may be raised or lowered at once, and in any degree, as the observer pleases. I may mention that on several occasions, when the instrument was working at full power and the spark-terminals were drawn 7½ or 8 inches apart, strong discharges burst across between the two induction-wires, at the rate of about one per second, without cessation of the principal discharge. The insulation was so good that the dielectric was not in any way damaged. The discharges took place through the air in dense white sparks, from end to end of the block, a distance of 7 or 8 inches. In these circumstances, the part of the glass block between the induction-terminals must have been subjected to a strain little short of the utmost it could bear. Electric forces of such intensity were hardly ever applied in the experiments, were not indeed required.

3. The polariscope consists of two Nicol's prisms. A flat paraffin flame, presented edgeways, is used as a source of light. Next to the lamp, and close to it, comes the first Nicol; then at a distance of 2 feet or more comes the dielectric of plate glass; then at a like distance comes the second Nicol. The pieces are so arranged that the observer, looking horizontally through the polariscope, and keeping the first Nicol at the centre of the field of vision, sees the flame through the centre of the dielectric, midway between the induction-terminals. The light crosses the dielectric at right angles to the plate-faces, and therefore at right angles to the lines of force.

4. *Neutralizing Plate.*—Every very thick plate of glass which I have yet worked with exerts at most of its points a slight depolarizing action upon transmitted light. When such a plate is inserted

* Faraday's "Experimental Researches," 2216, p. 951, or Maxwell's "Treatise on Electricity," vol. ii. p. 399.

between the two Nicols without compensation, anything like perfect extinction is generally unattainable, and the sensibility of the polariscope is lost.

The principal section of the first Nicol being in any desired position, and that of the second Nicol perpendicular to it, the dielectric (still unexcited, though connected with the coil) is inserted properly between the Nicols, and the light reappears well in the polariscope.

The neutralizing plate, a piece of glass about 6 inches square, taken from the same original plate as the dielectric, is then placed upon a stand immediately in front of the second Nicol, and is moved by trial into such a position that the restored light is again extinguished perfectly by a very small rotation of the analyzer. The apparatus is now ready for work.

5. The highest powers applied in the experiments are sufficiently indicated thus:—Battery in the primary circuit, a series of six Grove's or Bunsen's elements; corresponding spark-length, 9 or 10 inches; actual spark-length, or thickness of air between the spark-terminals, 6 inches, rarely 7; thickness of glass between the induction-terminals $\frac{3}{16}$ inch. But powers a good deal lower give effects distinct enough.

6. *First experiment.*—The pieces are arranged in the order and manner just described (2, 3, 4). The spark-terminals are fixed at a distance of 5 or 6 inches; the polarizing Nicol is laid with its principal section at 45° to the horizon; and the analyzer is turned, with the help of the neutralizing plate, into the position of perfect extinction. No piece of the apparatus is now touched, except the commutator, till the end of the experiment.

Looking through the polariscope, the observer closes the primary circuit. In about 2 sconds the light begins to reappear through the dielectric, at its old place between the induction-terminals, very faintly at first; but it brightens continuously for 10, 20, even 30 seconds, till it is almost brilliant. When the primary circuit is now broken by the commutator, the light fades away continuously, at first rapidly, then more slowly, to perfect extinction. The time that elapses (in the latter part of the experiment) between the opening of the primary circuit and perfect extinction in the polariscope depends very noticeably upon the intensity and duration of the electrification, increasing as these increase.

7. The light thus restored by electric action cannot be extinguished again, at any stage of the experiment, by any rotation of the analyzer either way.

8. *Second experiment.*—The polarizing Nicol is laid with its principal section either horizontal or vertical; the analyzer is turned into the corresponding position of perfect extinction; all the other arrangements and the procedure are as in the first experiment. There is now no regular effect obtained in the polariscope. In many cases, indeed, even when the strongest electric action (5) has been kept up for 20 or 30 seconds, any recovery of the light is very doubtful, rather a guess than a perception.

Small effects do sometimes present themselves; but they are trifling and irregular in comparison with those obtained in the first experiment. They are probably due to known causes, such as imperfection of adjustments, irregularities of molecular structure in the dielectric, possibly also slight changes of temperature. If a small and irregular allowance be made for one or more such disturbing influences, there is now no effect in the polariscope.

9. *Third experiment.*—Distance of the spark-terminals small (say, 2 inches), the arrangements otherwise as in the first experiment. The electric action is kept up for a minute or more, till the intensity of the restored light is certainly constant. The spark-terminals are then separated all at once to a distance of 6 inches, and in a second or two there is an evident increase of effect in the polariscope. Simple arrangements will be described soon, which exhibit this increase of effect as a reappearance from extinction.

10. *Fourth experiment.*—The same as the first, except that the primary current, instead of being constantly in one direction, is regularly reversed by the commutator at successive equal intervals of time (say, every second). The optical effect is as good as in the first experiment, if not better.

11. *Summary.*—When plate glass is intensely dielectrified, and traversed by polarized light in a direction perpendicular to the lines of force, it exerts a partially depolarizing action upon the light, giving an effect which is much more than merely sensible in a common polariscope. There is a good regular effect when the plane of polarization is at 45° to the lines of force, no regular effect when the plane of polarization is parallel or perpendicular to the lines of force. Electric force and optical effect increase together. The optical effect of a constant electric action takes a certain time (apparently about 30 seconds in my observations) to reach its full intensity, which it does by continuous increase from *zero*; and it falls again slowly to zero after the electric force has vanished. There is as good an effect with a rapid succession of contrary (Ruhmkorffian) electrizations as with a continued (Ruhmkorffian) electrization in one direction.

12. *Optical Compensator.*—Not having a regular instrument of this kind, I supply its place by a simple slip of glass held in the hands and subjected to varying stress. The action of strained glass upon transmitted light has been exactly determined by experiment. Compressed glass acts as a negative uniaxal crystal with its axis parallel to the line of compression; stretched glass acts as a positive uniaxal with its axis along the line of tension.

Illustrative optical experiment.—All the pieces placed as in the first experiment (2, 3, 4), the plane of polarization at 45° to the horizon, the extinction in the polariscope perfect, and the dielectric always unexcited. Two additional pieces are introduced into the course of the beam—say, between the dielectric and the neutralizing plate. The first is a small square of thin plate glass, held edgeways in a vice with its surfaces perpendicular to the beam, and feebly compressed in the direction of its length, which is horizontal. When this piece is inserted, the light is well restored from extinction. The second piece is the compensator—a rectangular slip of plate glass, shaped like a common microscopic slide, but generally larger. It is held by the two hands in front of the neutralizing plate, with its surfaces perpendicular to the beam, and its long edges horizontal; it is

gently bent by the hands, the axes of the couples applied being perpendicular to the plate-faces, so that (say) the upper parts of the slip are extended horizontally, and the lower parts compressed; and it is lowered or raised so that the light, after traversing the first piece, is transmitted to the analyzer through the upper or lower parts of the second piece. Through the extended parts the light is weakened, and, with a right degree of tension, extinguished perfectly, and with a greater tension restored again; through the compressed parts it is always strengthened.

Generally, when the directions of stress in the two pieces are parallel, compression and tension counteract each other; two compressions or two tensions reinforce each other. When the lines of stress are at right angles, two compressions or two tensions counteract each other; compression and tension strengthen each other.

The action of a strained piece in the polariscope is most distinct when the direction of the stress lies, as it does here, midway between the principal sections of the two crossed Nicols. There is no action when the direction of stress lies in either of these planes.

There are several variations of the illustrative experiment that ought to be noticed here for their bearing on what follows. The first piece may be stationed on the other side of the dielectric; it may even be removed altogether, and the compression or tension applied to the dielectric plate itself in a horizontal direction perpendicular to the beam; the results are then the same as formerly. It appears thus, without reference to theory, that horizontal compression of the first piece has always to be compensated in the same way (that is, by horizontal tension of the second piece), whether the first action is applied before the dielectric, or behind it, or in it.

The illustrative experiment takes its simplest form when dielectric or neutralizing plate are both removed. It appears thus that horizontal compression of a first piece has to be compensated in the same way (that is, by horizontal tension of a second piece), whether the other two mutually balanced pieces, the unexcited dielectric and the neutralizing plate, are present or absent. Accordingly, and without reference to theory, in proceeding to characterize the birefringent action of the excited dielectric by means of the compensating slip, I assume that the mutually balanced actions of unexcited dielectric and neutralizing plate are without effect, and therefore to be left out of account.

13. The compensating slips used in the following experiments were of different sizes. But there was one which I came at last to employ almost exclusively, as I found it well adapted to the whole range of effects examined. It was a rectangular piece of very good plate, $\frac{3}{16}$ inch thick, 2 inches wide, and 10 long. It had no sensible action in the polariscope while unstrained.

(To be Continued.)

MAGNETISM OF STEEL.

As Influenced by its Carbon and its Hardness.

For the measurement of the magnetism which different varieties of steel are capable of receiving, according to the carbon they contain and their degree of hardness, M. Trève (*Comptes Rendus*, abstracted by Stummer's *Ingenieur*) had fifteen steel rods prepared, which he grouped into five rows of three each. Each group had a varying proportion of carbon, viz., A 0·950 per cent.; B 0·550; C 0·500; D 0·450, and E 0·250 per cent. The rods in each group received a different hardening: No. 1 was heated up to 767 deg. C., and hardened in water of 10 deg.; No. 2 was heated to 800 deg., and hardened in water of 100 deg.; No. 3 was heated up to 776 deg., and hardened in oil of 10 deg. The rods were magnetised to saturation, and their magnetism measured. The results of these measurements are given in a table, from which we make the following deductions.

Rod A, with hardening No. 1, gave the highest magnetism, viz., forty-seven; with hardening No. 2, the magnetism measured forty-four; with No. 3, it measured forty-three. A comparison of rods A and E, both at hardness No. 1, show the great influence of the carbon, since, while the magnetism of A was forty-seven, that of E was only thirteen. The influence of the hardening is small when the proportion of carbon is large, but becomes more manifest as the proportion of carbon decreases. The measurements show with precision the influence of the proportion of the contained carbon; the magnetism rising with it, as shown by the following table:—

A_1	47	B_1	45	C_1	42·5	D_1	33·5	E_1	13
A_2	44	B_2	30	C_2	30	D_2	22	E_2	10
A_3	43	B_3	37	C_3	37	D_3	29	E_3	12

M. Trève has constructed curves according to these values, showing these results more plainly. A comparison of these curves with the curves of elasticity of these steels shows that as the carbon gives steel its elasticity, it bestows upon it also its magnetic capacity.

To Correspondents.

Learner.—We do not answer enquiries from correspondents who do not affix their names and addresses.

Student.—Ferguson's Electricity is one of the best books for the beginner. He should carefully make every experiment himself. We shall probably review Professor Guthrie's new book in our next number.

A.B.C.—Yes; just so.

*** Duly authenticated contributions, theoretical and practical, on every subject identified with the interests to which "The Telegraphic Journal" is the organ, will always command attention. Anonymous correspondence will be wholly disregarded. Literary communications and books for review should be addressed to the Editor; business communications to the Publishers, 10, Paternoster Row, E.C.

Flashes, like Auroras, are said to have been seen over the dark atmosphere of Venus.

Carbonate of Ammonia reduces the resistance of water considerably, but Ammonia itself does not.

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THE APPLICATION OF THE ELECTRIC CURRENT TO THE EXTINCTION OF FIRE.

By A. TOLHAUSEN.

It is a thing not generally known, that amongst the various modern applications to which the electric current has been applied, it has also found a suitable adaptation in the extinction of fires.

The agency by which this is accomplished is steam, and although the discussion of the latter with respect to its valuable properties in the extinction of fire, is not the object of this paper, still the following cursory remarks on its merits will not be out of place.

The action of steam in the quenching of flame is twofold; in the first place it prevents the access of air to the burning combustibles, and in the second place it acts as a reducer of temperature. Taking this assertion (the substantiation of which would carry us beyond our present limits) for granted, the idea to envelope, as it were, burning bodies with volumes of steam to ensure their extinction is not new, but as far as the writer of these lines is aware, the introduction of the electric current as an adjunct to steam for this purpose, is novel.

The superiority of steam over water once conceded, the next thought which must have presented itself to its supporters, was its most suitable application. In most manufacturing concerns steam is abundant, and services of steam pipes may be often found laid through the factories for warming purposes; consequently, in such cases, the interior of any such building might be easily filled with steam should a fire break out in any of its rooms, by merely allowing the steam to rush out of these warming pipes. It was further sought to render the escape of steam in fire-ontbreaks, automatic, or self-acting, so as to make it entirely independent of any attention. This thought led to the application of the *electric current* in the automatic extinction of fires. The aim of this invention is to secure the steam being turned on by means of *electricity* when a given degree of heat has been attained. For this purpose, thermometers which are connected by means of wires with a galvanic battery, and an electro-magnet attached to the apparatus, are placed on the ceiling or other parts of the building to be protected against fire. In order to set the apparatus in motion, there must be an electric circuit completed, which is done in the following manner:—When a fire breaks out, the heat causes the mercury in the forementioned thermometer to rise and to come in contact with the wires leading to the battery and the electro-magnet—in other words, when the mercury rises to the point which has been fixed upon, the circuit is completed, the apparatus operates, and steam escapes into the room. When the electric circuit is completed, the electro-magnet attracts its armature, forming one arm of a lever, the other end of which holds in a notch the pin of a weighted single lever, standing almost perpendicular, and being only so much inclined as to have sufficient tendency to swivel on its centre, to fall upon a third lever depressing one of its arms and raising the other, thereby releasing a pin on the rim of the valve wheel. This being now liberated, it revolves in the direction in which it is drawn by a weight, suspended on a chain and wound upon its rim, thus opening the valve and admitting steam into the apartment through a pipe which is branched off the main steam pipe.

It is perhaps unnecessary to remark here, that although the number of thermometers may be augmented to any extent whatever, still a single battery will suffice for all; care must, however, be taken that the wires be kept apart from each other so that the electric current may at all times become established. The thermometers may be conveniently placed at a distance of from twelve to fifteen feet apart, but should a prominent place offer itself favorable to the breaking out of fire, it will be well to place an additional thermometer in such a situation.

Without entering into the constructive details of the apparatus and service pipes, the following description of two trials with this automatic fire-extinguisher will show the efficacy and surety of the apparatus. The first of these was conducted in a large room, 72 feet long by 27 feet wide. Two cart-loads of wood were deposited in this room, and after besmearing the wood with oil, it was further tarred all over. After fire had been set to this wooden pile, the doors of the room were closed, and the persons present retired to watch the effect from the outside of the room's windows. Of course the room had been fitted up for the reception of the automatic fire extinguisher, and the thermometers had been so arranged, that metallic contact should take place at 140° F. Less than two minutes elapsed between the time of ignition and the time required to raise the room's temperature to 140° F., when the steam valve opened automatically, and after three minutes and a-half longer, all flame had been extinguished.

The second trial which we propose to recapitulate took place at Halifax towards the end of last year, and in the lower Apsley Mill. The latter, a very old and greasy mill, offered uncommonly good facilities for rapid destruction by fire. It is three stories high. A large quantity of firewood and shavings were lightly stacked together in the basement storey, which is 75 ft. long, 22 ft. broad, and 14 ft. high. A committee of several gentlemen, to whom the mode in which the trial should be conducted was left, ignited the fuel in several places at the same time. The door of the mill was then closed, and the fire spread and grew rapidly; the flames licked the ceiling above, and appeared seriously to menace the safety of the building. The degree of heat was fixed at 100 degrees, which was very speedily reached. The steam was then heard rushing into the room with great force, and after a little while it first arrested and then rapidly overcame the flames. At this time there were 40 lbs. pressure of steam in the boilers. In a quarter of an hour from the lighting of the fire the door of the mill was opened, but it was found that the fire was still smouldering. Hence the doors were closed for 20 minutes longer, by which time the smouldering had been effectually overcome. An inspection of the room showed that scarcely any damage had been done, the ceiling and even the

boards on which the fire had been built disclosing very few and slight traces of fire. A second novel feature in the present trial was that, as soon as steam entered the room, an alarm bell outside the mill began to ring. This alarm bell can be easily placed in a bed room at any distance from the mill, and is so constructed that it will indicate the very room in which a fire breaks out. A buzzer may be also sounded by the machine, but as these appendages are only of secondary importance in our present object, we will conclude this article by stating some of the advantages which the application of the electric current in the extinction of fires may be said to enjoy in combination with the aforementioned apparatus. It is always ready for action, it will operate the moment it is actuated by the fire itself; it combats, therefore, in its infancy; it will act equally upon all combustibles; it does not depend on human skill or vigilance; it does not endanger life, no operators being required; it does not facilitate the access of air; it is independent of extraneous influences, such as the supply and pressure of water; it is less liable to get out of order than most other appliances; it will, at the worst, confine the fire to the room in which it breaks out, and it will, therefore, restrict the loss and inconvenience from fire and water to a *minimum.*

TRANSMITTING MUSICAL TONES BY ELECTRICITY.*

By ELISHA GRAY, of Chicago.

THIS is a method of producing musical tones of any desired pitch at any point in an electrical circuit, and consists in transmitting a series of impulses of induced electricity of high tension, corresponding in number to the number of audible vibrations constituting the said musical tone, through living tissue in contact with any resonant substance, or through a coil surrounding a bar of iron or the core of an electro-magnet, the succession of currents being produced by an induction coil or other apparatus for inducing a secondary current, and being caused by the action of any suitable circuit interrupter situated in a primary circuit.

And in order that the said invention may be fully understood, I shall now proceed more particularly to describe the same, and for that purpose shall refer to the several figures, the same letters of reference indicating corresponding parts in all the figures.

Fig. 1 of the drawings represents one form or plan of an electrical apparatus in which these improvements are embraced; fig. 2 is a front elevation of the same, and fig. 3 is a diagram showing an arrangement of parts and circuits which may be employed in connection with these improvements.

A represents the base or frame of the apparatus; B is an induction coil of the usual form provided with the usual primary and secondary helices; C is an ordinary vibrating electrotome, which, when in action, produces a musical tone, by the vibration of its armature and circuit breaking spring *a* of a pitch determined by its rate of vibration, which rate is dependent upon the length, stiffness, and adjustment of the spring attached to the armature of the electrotome; C^1 is another electrotome similar to the first, with the exception that its spring a^1 is so adjusted that it produces when in action a musical tone of a different pitch from that produced by the electrotome C, owing to the different rate of vibration of its circuit breaking spring a^1. Other electrotomes may be provided having their vibrating springs so constructed and adjusted that when in action the series will produce tones extending through one or more octaves. These electrotomes are situated in the primary circuit of the induction coil B, and when the said primary circuit is broken by the vibration of the circuit breaking springs, secondary currents are induced in the secondary circuit of the said coil.

D, D^1, are telegraphic keys of the usual form placed in the primary circuit above referred to, which circuit is divided so that it passes through both keys and both electrotomes. The keys are used for making connection with the battery.

Figs. 3 and 4 shows the arrangement of the circuits; G being the secondary circuit extending from the induction coil B to the receiving station; F, the battery; and H, the primary circuit from the battery through the keys; D, D^1, magnets of the electrotomes C, C^1, and the primary circuit of the induction coil B. E represents a suitable resonant substance at the receiving station, and consists of a hollow cylinder of metal.

The method of operation of the apparatus is as follows:—On depressing either of the keys D, D^1,

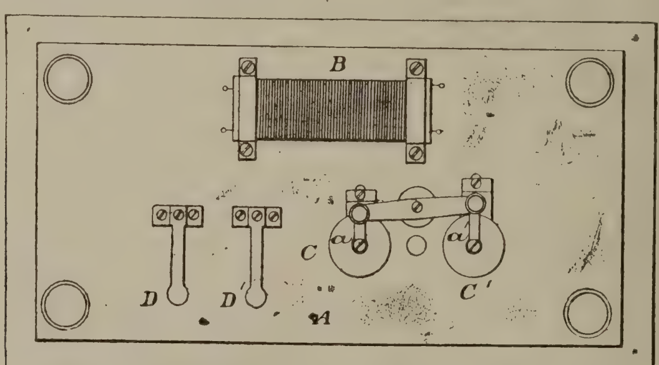


FIG. 1.

* Taken from the Specification.

the primary circuit from the battery F will be closed through one of the electrotomes, and the spring or circuit interrupter of the latter will immediately commence to vibrate, producing a musical tone of a certain pitch dependent as before stated on the size and adjustment of the spring, and interrupting the primary circuit of the induction coil B. These interruptions will induce secondary currents in the secondary circuit of the the body of a violin by metallic strings, or a sheet of foil paper stretched over a metallic ring, or any other suitable resonant substance, the impulses of electricity transmitted through the living tissue of the operator will, from some cause not yet fully understood, produce a corresponding number of vibrations in said resonant substance, and a musical tone will be given forth of a quality dependent upon the character of the resonant sub-

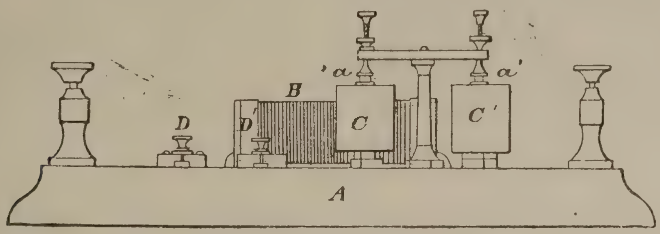


Fig. 2.

said coil, which will correspond in number with the vibrations of the circuit interrupted, and the number of musical audible vibrations constituting the tone produced. Thus, for example, if the circuit interrupting spring vibrates one hundred and twenty-eight times per second, the tone produced is that known as the "fundamental C," and at the same time one hundred and twenty-eight terminal stance, but of the same pitch as that produced by the vibration of the circuit interrupter at the transmitting end.

Instead of interrupting the primary circuit by vibrating automatic electrotomes, and thereby inducing the secondary current of high tension which is transmitted to the resonant receiver, the necessary interruptions for this purpose may be

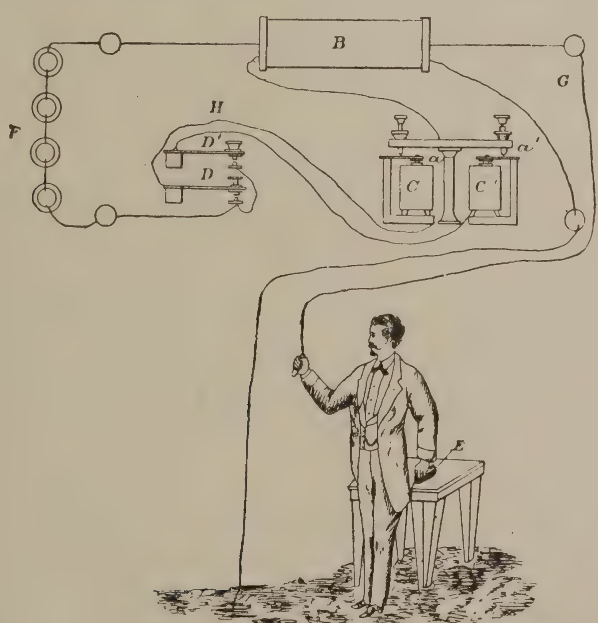


Fig. 3.

induced currents will be generated in the secondary circuit.

If now a person places himself in the said secondary circuit and brings his hand or any other part of his body in contact with any resonant substance which is a conductor of electricity, so that the circuit is completed through it, the said resonant substance being either the metallic cylinder shown at E, or a plate of metal stretched above effected by any mechanical device which will produce a sufficient number of interruptions per second to cause a musical tone.

The secondary coil may be dispensed with and the secondary currents induced in the primary coil, when the primary circuit is interrupted, may be transmitted to the receiver for the purpose of producing the audible vibrations.

Another form of the apparatus is constructed as

follows :—The transmission of sound is effected as in the apparatus above described by the conversion of electrical impulses of high tension through a secondary circuit into audible vibrations, but the apparatus is based upon the principle that an electrical current traversing a coil surrounding a bar of iron or the coil of an electro-magnet, causes a slight elongation of the said bar or core, which elongations, if they succeed each other with sufficient rapidity, will result in a vibration of the bar, and the production of a musical tone. This apparatus is shown at fig 4, the transmitting apparatus being the same as in the apparatus before described, but the receiving apparatus as shown at E, consists of an electro-magnet placed in the secondary circuit; S represents a hollow cylinder of metal which is placed upon the poles of the electro-magnet and intensifies the sound.

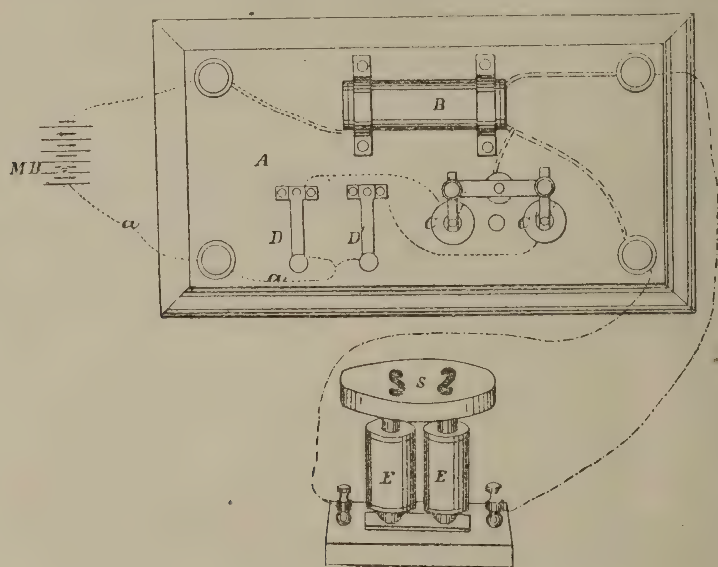


FIG. 4.

The uses to which the apparatus may be applied are various. In telegraphing for example, instead of transmitting messages by means of the Morse alphabet now in general use, tones of different pitch corresponding to the letters may be employed, which tones can be produced more rapidly than printed or impressed dashes can be made, and their duration would be shorter than the intermissions now required for producing dashes and dots in succession.

A very slight interval would be necessary between the tones to indicate the separation, and as dashes would be indicated by one tone, and dots by another, all signals would have the same length. Instead of using one tone for dashes and another for dots, signals could be devised consisting of tones of various combinations. These signals can soon be readily learned and read by any operator capable of distinguishing tones of different pitch, who by placing his ear in contact with the resonant substance, would cause the tones to be produced, and still have both hands free to receive the message. By means of a type writer an operator could record about eighty words a minute.

The amount of current which is necessary to produce the effect is almost unappreciable. Less than one-hundredth part of the battery power now required enables audible signals to be transmitted over long lines. The apparatus can therefore be employed with advantage on submarine lines, and the rate of transmission over them can be thereby much increased.

As a telegraph apparatus it is simple, economical, and rapid in its operation.

The apparatus may also be employed to transmit tunes from one place to another; the vibrating pieces being properly pitched and sufficient in number, even the different parts of a musical composition each simultaneously played in different places may be transmitted to the same place, so that the whole will be there audible. In the latter case a separate circuit and transmitting and receiving apparatus will be required for each part of the musical composition, and it will be necessary to beat time by telegraph for each set of performances.

THE WORD TARIFF.

THE Eastern Telegraph Company have given notice that the *word* tariff and the new rules and regulations based on the recent International Telegraph Convention held at St. Petersburg, will come into operation on January 1st, 1876. The price of a message to Egypt becomes 1s. 7d., to India 4s. 6d., and to China 8s. 4d. per word, the sender having to pay for every word in the message. The Company will register free of charge the names and addresses of firms receiving messages, so that the number of words in the addresses shall be reduced to a *minimum*. In fact, two words, "Hercules, London," are all that is required. Nor need the name of the sender of a message be transmitted, for the last word of the message can be made to represent the sender. Thus the bugbear of long addresses is entirely swept away.

The *maximum* length of a word in European messages is fixed at 15 letters, and for extra-European messages at 10 letters. Each group of five figures will be counted as a word, the excess over five being an additional word. Every separate character, whether a figure or a letter, or even an underline will be counted as a word. Signs of punctuation, hyphens, apostrophes, inverted commas, will not be regarded or signalled. A few abbreviations will, however, be accepted as one word. These are—

R.P. (Response payée)—answer prepaid.

T.C. (Telegramme collationné)—repeated message.

C.R. (Accusé de reception)—acknowledgment of receipt.

P.P. (Poste payée)—postage prepaid.

X.P. (Exprès payée)—express prepaid.

Accuracy in transmission can be ensured by the sender having his message repeated back, and he can have this done on payment of half the usual rate additional. The repetition of all messages written in secret figures or letters is made compulsory, while figures will only be accepted in code messages, or messages not in plain language, on the senders declaring that they have no secret meaning. Messages composed of secret letters will not be taken at all except from the Government.

The sender of a message can learn whether it has been duly and properly delivered, and at what hour and date, by paying for a message of 10 words, and inserting immediately after the address the words, "acknowledgment paid," or its abbreviation, "C.R."

Replies can be prepaid, but they will be restricted to three times the number of words contained in the original message. On the Continent messages can be sent so as to follow a receiver, if he has left the first address, on his paying for the second message on its delivery. For instance, a message may be addressed "John Smith, Bernerhof Berne, or Sweitzerhof, Zurich, à faire Suivre."

Many other minor rules, respecting modes of payment, reimbursement and multiple messages, will come into force, but we have indicated generally the principal changes, which must have a very serious effect upon that business which is called "packing."

BLOCK SIGNALLING.

(Continued from page 248.)

With all the foregoing forms of signal instruments electro-mechanical bells were employed, that is, bells rung by mechanism, the mechanism being put in motion or released by the electric current. These bells were used principally as alarums to call attention, and were scarcely fitted for any other purpose. To be in good order they must be kept wound up and well adjusted. The former operation had to be performed by the signalman, and was not unfrequently forgotten. The latter required the attention of the Inspector or Lineman with every marked alteration of the power of the current whether caused by leakage on the line wire or by reduced battery power.

The first bell really adapted to railway signalling purposes, or for any signalling purposes, where a code of signals was required to express different meanings, was introduced by Mr. C. V. Walker, F.R.S., on the South Eastern Railway in 1852. It is worthy of remark that the same description of bell is still in use. Its construction is as simple as possible, being merely a pair of electro-magnetic coils wound with large (No. 16 and No. 18) copper wire insulated with cotton, and an armature placed in front of the poles of the electro-magnet, carrying the hammer required to strike the bell. A great feature to be noticed in the formation of this instrument is the size of the wire. Up to the date of its introduction no such gauge wire had been used for telegraphic apparatus. That its inventor thoroughly understood his subject is shown by the satisfactory result obtained. It is now generally understood that to obtain the maximum effect on any instrument its resistance should as nearly as possible equal the resistance of the line and battery. The battery, which Mr. Walker employed with his bells, and which was also a new invention at the time, was the graphite battery, a battery of large quantitative power and little internal resistance, hence the success attending the use of the large wire for the coils of the bells.

Successful, however, as was, no doubt, the introduction of this instrument—for it was speedily adopted and applied on the South Eastern line—it scarcely comes within the term of a block signal instrument. That it was for many years used as such on the line mentioned, and used with great success, is a fact beyond dispute, and as such speaks volumes in praise of those in whose hands it was placed for the regulation of the traffic. The railway traffic of those days was not, however, the railway traffic of the present date, and it may be safely assumed that railway managers of to-day would hesitate before adopting for the protection and regulation of the increased and increasing traffic of the present period an instrument which gave no indication of the signal conveyed beyond that of the sound of the bell. If proof of this were wanting, it may be found in the fact that of late years Mr. Walker himself has applied such an indication to his system. That the necessity for it it was felt by the signalmen themselves, was shown by Mr. R. S. Culley, now the Engineer-in-Chief of the British Postal Telegraph system, during the discussion on a paper on "Railway Telegraphs" by Mr. W. H. Preece, read before the Institution of Civil Engineers in 1867.

Having referred to his long experience in the management and maintenance of telegraphs and systems of train signalling, in Scotland, and on almost all the lines of railway in the West, the Midland Counties, and the North-West of England, he proceeds to remark:—"He had found the system "of permanent signals preferred to those in which "the same wires were used for both lines of rails, and "by which trains were simply reported as *in* or *out* "of a tunnel. It was true that the want of a per-"manent visible signal was in some measure com-"pensated for by the entry of each signal in books "provided for that purpose; but, unless the entry "was made at the moment, there was danger that "it might be neglected and the book be made up "afterwards. At Springwood, near Huddersfield, "there were two tunnels, connected by a short, "open cutting, in which cutting was a junction

"with another line—a most difficult point to work. There were three cabins with telegraphs. So "much were the men impressed with the necessity "of having a permanent signal, that they invented "one of their own, consisting of a piece of red rag, "placed on the instrument when there was a train "in the tunnel, and removed when it was reported "clear."

Fully alive to this, we find Mr. Tyer entering the field in the same year as that in which Mr. Walker produced his bell, with an arrangement which, although having its disadvantages, yet possessed many advantages over the form of instruments then in use for railway block signalling. Hitherto train signalling instruments had been the adaptation of the speaking telegragh instrument or merely by bell. In the former the signals were sometimes transitory, sometimes permanent, but the instrument was available at any time for conversationa purposes. The bell was free from this latter objection, but its signals were also transitory, and dependable entirely upon the sense of hearing or sound. Mr. Tyer aimed to secure for his arrangement that which recommended itself in both of these systems—a permanent signal, and a permanent record of that signal so long as it should be required, whether to indicate train on line or line clear; combined with a single stroke bell on which any number of clear and distinct beats might be given.

Figure 6 represents the earlier arrangement employed by Mr. Tyer. It consisted of an indicating or block instrument, a bell, and a gong. Up train signals were sounded on the bell, down trains on the gong. The face of the indicating instrument was divided into two portions, each of which was provided with a pointer or indicator having two movements—to the right and left. The upper portion was devoted to up trains, the lower to down trains. Below the indicators, two keys, termed plungers, were arranged so that pressing either of them inwards brought the battery in circuit with the wire, and so transmitted a signal to the corresponding signal station. On the key resuming its position of rest, the line was placed in circuit with its respective indicator. Whilst one key was employed for the "block" signal, the other was devoted to the "clear" signal. Care was requisite in manipulating these keys or plungers so that the wrong one might not be pressed, and thus a wrong signal sent—as *blocked* for *clear*. In Mr. Tyer's later form of instrument this difficulty has been greatly, if not entirely obviated. Of the two pointers referred to above, the upper one was the *block* signal, by which the up traffic was governed, the lower merely the indicator worked by the outgoing current , showing the signalman the last signal sent by him to the adjoining signal station for the control of down train. Although not strictly reliable as such, being worked by the outgoing current, yet, when all was right it formed a truthful repetition of the signal last sent to the distant box, and as such was of great value to the signalman. The upper or block indicator could only be altered by the signalman at the distant box n the direction of which the train was proceeding; the signalman at any one station had thus no control over the block signal governing trains at his station and in this lies the chief of the improvements effected by Mr. Tyer.

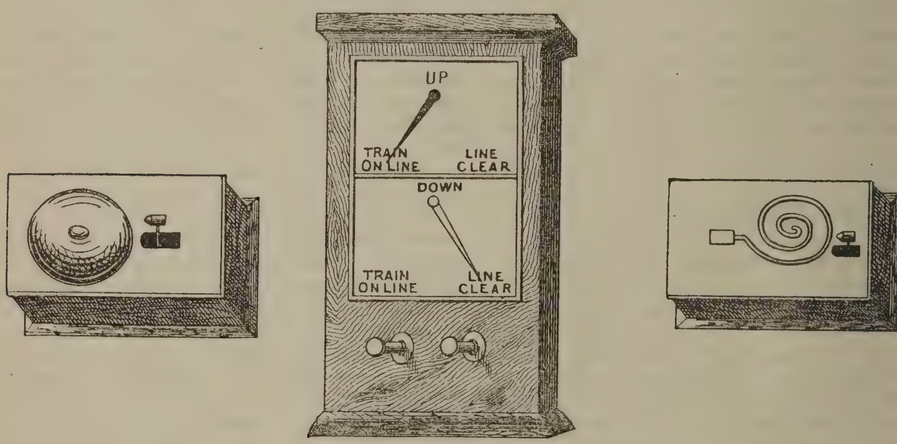


FIG. 6.

ON A SYSTEM OF TELEGRAPHY.

A COURSE OF LECTURES, DELIVERED AT THE SCHOOL OF MILITARY ENGINEERING, CHATHAM.

By W. H. PREECE, Member Inst. C.E., &c.

LECTURE III.—COMMERCIAL TELEGRAPHY—PART II.

(Continued from page 244.)

HAVING in my last lecture sketched the growth and present state of the plant of the system of commercial telegraphy in England, and the character of the operators engaged in its working, I purpose now to examine the internal organization, established for the maintenance of the wires and apparatus, and for the transmission of messages.

We must assume the system constructed and in full operation. We will also assume the whole system under the united control of one administration. There must necessarily be two branches:—the one engaged in securing the upkeep of the wires and the working order of the apparatus, the

other engaged in the manipulation of the instruments and the distribution and disposal of the messages. The first is called the *Engineering*, the second the *Commercial* branch.

1. *Engineering Branch.*—The unit of this system is *the lineman's length*. The unit varies with the character of the telegraph and the number of offices within the sphere of action. On a heavy trunk road line like that proceeding from New Cross through Tunbridge to Beachy Head, one man is appointed to about 25 miles of line. On a lighter line one man is appointed to from 30 to 40 miles of line. On a railway, one man can take from 80 to 120 miles of line. These lengths would be decreased with the number of instruments under his charge. The average length is about 25 miles of trunk road, 25 miles of branch lines, and 15 offices, averaging 25 instruments.

The lineman's duty is to patrol his line periodically to see that no defects exist, and to remedy any that appear. To maintain the poles firm and intact, the stays and struts in order, the insulators whole and sound and tightly screwed up, and the wires properly jointed, regulated, and clear of trees. He must visit each station under his charge periodically, to clean, oil, and examine his instruments, to clean and refresh his batteries and keep them in working order, to pay especial attention to the condition of the leading-in wires, and to maintain the earth connections sound. The regulations are that he visits each head-office once a month; each sub-office, if a needle station, once in every two months; if an A B C station, once in every three months. Every lineman has a depôt in which he retains a small stock of tools, instruments and stores, which experience has shown necessary for maintenance purposes.

Over every four or five linemen, according to the geographical character of the country and the direction of the lines, an *Inspector* is placed, who resides in some central spot, and whose territory is called a *section*. It is his function to see that the linemen carry out their duties, and for that purpose to periodically inspect their lengths *on foot*. Experience has shown that the inspection of telegraphs in any other way than on foot is a myth, for the rapid view taken in a trap or in a coach allows defects to be passed which speedily ripen into serious faults. Faults will arise spite of all forethought and care on the best organised lines. Wet weather opens out wounds that are imperceptible in dry times. The position of a pole may be disturbed by a hundred different adventitious circumstances, and the wires upon it thrown out of regulation and brought into contact. Lightning and storms of wind may bring down branches and trees upon the wires, and many accidents arise from falling boulders and rocks; overladen wagons may bring the wires together at crossings unless they are maintained at proper heights and in proper regulation. Passers-by amuse themselves by lashing at the wires with their whips, and not unfrequently find to their chagrin that a portion has been left behind upon the wires. Boys take an exceeding delight in flying their kites in proximity to the wires, and lose their tails as well as their kites. Engine drivers frequently throw away their waste, which the wind in its wantonness deposits upon the wires. Various moving accidents by flood and field tend to disturb the wires, and it is only the watchful surveillance of the inspector which prevents their rapid conversion into serious breaks down.

Telegraphs can only be maintained in working order by incessant, constant, and personal inspection, and the efficiency of a well-constructed telegraph—its freedom from faults—is the measure of its supervision.

There are three general kinds of faults experienced on telegraphic circuits, which are subdivided into three species.

1 *Disconnections*, which are indicated by the total or partial cessation of the current. These are further divided into—

(*a*) *Total disconnection*, such as that produced by a wire broken within its insulating covering, an open switch in an office, a fused wire in a coil, a wire off its terminals, &c.

(*b*) *Partial disconnection*, such as that produced by an unsoldered joint, a dirty contact, improperly applied lacquer, a loose terminal, a bad earth, &c.

(*c*) *Intermittent disconnections*, the results of a bad joint which moved by the wind, by passing objects, or by heat, makes and breaks contact at irregular periods.

2. *Earths*, which are indicated by the increase of the current at one end and its decrease or cessation at the other end. They are also subdivided into—

(*a*) *Dead earth*, such as that produced by the broken end of a cable in the sea, or of a wire resting on the damp ground, a wire resting on a stay or earth wire, a lightning protector with its two plates fused together, &c.

(*b*) *Partial earth*, such as that produced by cracked or defective insulators, by wires resting upon walls, posts, trees, &c., bad guttapercha wire, &c.

(*c*) *Intermittent earth*, such as that produced by the wire expanding under heat or moved by the wind, and touching some body in contact with earth.

3. *Contacts*, which are indicated by the currents from one circuit passing into another circuit, and are subdivided into—

(*a*) *Metallic contact*, such as that produced when wires are twisted together, hooked together at joints or joined together by other pieces of wire.

(*b*) *Partial contact*, such as that produced by bodies of high resistance—wet kite strings or whipcords for instance—connecting the two wires together, bad earths, and wet weather on badly insulated and unearth-wired lines.

(*c*) *Intermittent contacts*, such as those produced by the clashing together of imperfectly regulated wires in storms, in the hands of careless workmen, or by the flocks of birds which sometimes rest upon the wires; and frequently by loose pieces cf wire carelessly thrown upon the wires, and adhering to one of them whilst they are blown occasionally against the other.

The whole system of engineering organization is directed first to the prevention of these faults and secondly to their rapid removal should they unfortunately occur. It is, therefore, essential that the inspector have a thorough and constant knowledge of the condition of the lines, wires, and instruments under his charge. This he obtains not only by incessant personal inspection, but by daily and periodical electrical tests of the most search-

ing character. The inspector's section is so arranged that he can regularly and fully carry out these duties.

Every two or three sections are grouped into a *subdivision* over which is placed a *Superintendent*, whose duties are as much of a clerical as of a spectative character. He sees that all the rules and regulations of the service are fully carried out, he is paymaster and adjutant, he keeps all stock accounts, pays all the men, carries out works orders, supervises the inspectors, maintains a general inspection over the whole of his subdivision, and keeps a watchful eye over the condition of the circuits under his charge.

It thus appears that the supervision of a superintendent as well as that of an inspector is of two kinds—the one *active*, the other *passive*. The active supervision consists in close personal inspection of all work done, and of the actual visible condition of the plant. The passive supervision consists in the careful examination of the electrical conditions of the circuits under his charge. The electrical tests applied to the wires are daily and periodical.

The daily tests are of two kinds:—

(*a*) Those applied to sub-office circuits.

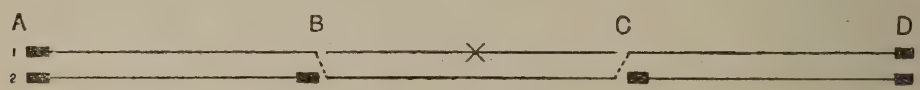
(*b*) Those applied to head office circuits.

(*a*) These are simple. Every sub-office, when the recognized operator comes on duty, is called by his head office. He watches the character of the signals he receives, whether they are of the usual strength or weaker than usual, whether they are readable or unreadable. If they are readable he replies "signals good" or "signals weak" as the case may be. If they are unreadable, or if the station's attention cannot be called, the head office knows that there is a fault on. If all circuits are good he reports to the inspector "all circuits right." If one circuit is broken down he reports "broken down to A, all other circuits right." The inspector in the latter event at once directs the lineman to go after the fault and to repair it as rapidly as possible.

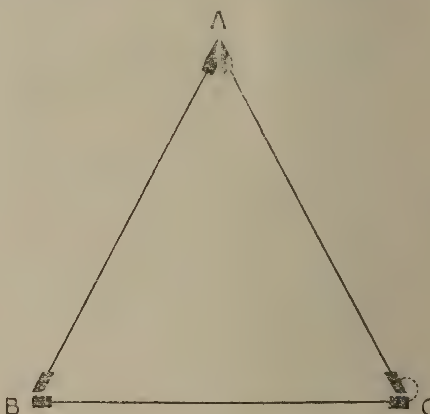
(*b*). Every head office circuit is examined every morning between 7.30 and 7.45 by a tangent galvanometer. It is an operation like that of looking at the tongue and examining the pulse of a patient. The circuits are divided into convenient sections and tested by a recognised and experienced testing clerk. A given electromotive force is applied to each wire which is disconnected at the distant end, and the current passing into the circuit is noted by recording the reading of the tangent galvanometer, and knowing the constants of this instrument, by a simple calculation, the condition of each wire is known.

At offices where there are many wires the tests have to be taken very rapidly, hence they are rough, but they are ample for the purpose and fully efficient. The great object is to obtain the earliest possible information of the condition of the circuits so as to be able to send off the line-man at once after faults, to remove them before the busy hours of the day commence.

Supposing that the wire when tested gives indication of the existence of such a fault as to interrupt the communication.—What is done?—The circuit if it is an important one, is made good by crossing with some other less important wire. The value of the importance of a wire as a rule is the number of messages it carries, but it may also serve some distant station which has no alternative route. Thus if a fault be on No. 1 wire between B and C, and the circuit between A and D be one of not much importance, then both wires at B and C are disconnected. The up portion of No. 1 wire between A and B is connected to that portion of No. 2 between B and C,

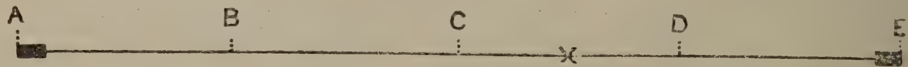


which is again connected to the down portion o No. 1, thereby making No. 1 good throughout. Or there may be another outlet thus:—Suppose the circuit A B be broken down, a mere cross connection at C restores the communication between A and B.



In any case when the existence of a fault is proved, its position is localized, and instructions are issued for its removal.

Practically on overground wires, faults are simply localized by disconnecting or by putting the wire to earth at successive stations until it is localized between two stations. At certain stations the wires are led into testing boxes where the wires are attached to terminals which give facilities for crossing, disconnection, and putting to earth.



First, the wire A E is to earth somewhere between A and E, A is the testing station. A first directs B to disconnect for one minute; he does so, the wire proves good; at the expiration of the minute he joins up again and C is directed to do the same;

he does so, and the wire again proves good. D then disconnects, and the wire proves bad, hence the wire is faulty between C and D. Secondly, the wire may be disconnected at the same place; the same operation proceeds, excepting that B C and D put the wire to earth in place of disconnecting it.

(To be Continued.)

ON TELEGRAPH CONSTRUCTION.

By JOHN GAVEY.

(Continued from page 247.)

Pole Fittings.

Arms and Brackets.—In this country wooden arms have been more largely used than any other means of attachment between the insulators and the poles. They possess several undoubted advantages over other methods of fastening, being more solid and secure, and improving the insulation of the wires, by offering a very perceptible resistance to leakages from the insulators. These arms should be cut out of the best English spine oak, and the dimensions generally adopted in England, after many years experience, are 24 and 33 inches long, by $2\frac{1}{2}$ inches square. When shorter than this, the wires they carry are liable to interruptions through contact, and if the transverse strength is diminished, they are apt to be broken off, or the ends split, when a wire breaks. Further, it has been found that in automatic high speed working, induction from wire to wire interferes materially with the rate of speed that can be obtained. By diminishing the length of the arms, this effect is materially increased. Each arm should be bored with three holes, two vertical, at 3 inches from each end, $\frac{3}{4}$ inch in diameter, to take the insulator bolts, and one in the centre, horizontal, $\frac{5}{8}$ inch diameter, for the pole bolt. Arms of this size, when properly selected, will serve all ordinary purposes, possess sufficient strength as intermediate supports, and will even hold wires when terminated on them transversely. They should be fitted with earth wires of No. 16 gauge, each wire taking two turns around the arm close to the pole. These wires should be only fitted after the arm is dry and has been painted, and no paint should ever be allowed to cover their surface.

Galvanized iron bolts, usually half-an-inch in diameter, and of varying lengths, are employed for attaching the arms to the poles. Some use bolts of heavier metal, but the former afford ample strength for the strains to which they are exposed. Each bolt should be provided with two washers, one 3 inches by 2 inches by $\frac{1}{4}$ inch, the other 2 inches by 2 inches by $\frac{1}{8}$ inch.

Brackets of wrought, cast, and malleable cast iron, of various shapes and sizes have been used. That most commonly adopted in this country is made of malleable cast iron, and consists of a hollow shank, four inches long, at one extremity of which is a convenient receptacle for the insulator bolt, the other extremity being provided with a kind of foot, pierced with three holes, which admits of its being fastened to the pole by nails or screws. Three-inch galvanized clout nails are ordinarily employed, though coach screws of a like length are sometimes used. They afford a better hold, but one difficulty with them is to get the men to treat them fairly. They generally drive them in instead of screwing them, and in such cases a nail had better have been used.

A modification, termed a bridge bracket, is adapted for driving into walls, bridges, and masonry generally.

Pole Roofs.—The primary object of a pole roof is to prevent the moisture and wet from entering the interior of the pole at the top, where a transverse section of all the pores of the timber is exposed. Roofs of many kinds have been imagined and used, from a circular disc of flat iron surmounted with a lightning protector, to elaborate turned or moulded tops where ornament is an object. Earthenware roofs have been very largely used, but all these have been almost wholly replaced by a single sheet of galvanized iron bent at right angles in the centre, and nailed to the top of the pole, the latter being cut to fit it. This effectually throws off the wet, and likewise affords a convenient position for a wire which is supported by a special bracket termed, technically, a saddle. Poles placed in or near towns are generally fitted with something more pretentious, and the engineer herein indulges his own fancy in designing a suitable ornament.

Stays generally are formed of wire stranded together, either by hand on the spot or by machinery. They are usually attached to stay rods at the ground line. These consist of galvanized iron rods varying from five to eight feet long, and from half to three-quarters of an inch in diameter. The most approved form have a square head wrought at one extremity, and an arrangement for tightening the stay at the other. This consists of a loop or shackle which fits on the top of the rod, and is held in any desired position by an ordinary nut on the latter. In exceptional cases continuous iron rods are employed. This will be fully dealt with later.

Stays are anchored in the ground by means of stay blocks, which are usually lengths of timber two to three feet long, and which may consist of any description of wood which is conveniently available. Where new timber is used, the most crooked, or that least adapted for use as poles, is selected and cut up, but it frequently happens that a large and useful supply of blocks can be obtained from old timber recovered during the renewals of other lines. If the poles have been dug out, the butts, especially when planted in clay or heavy soil, below the rotten portion form the best timber that could be used, being hard and well-seasoned.

The soundest and hardest of the upper portions of the old poles can, however, be used with advantage, especially if they are immersed in creosote. This can be effected at slight expense. A ship's water-tank is obtained, mounted on bricks so as to admit of a fire heing lighted under it; it is partially filled with creosote, and the blocks immersed. The useless portions of the wood form the fuel, and at any depôt a large number of blocks can thus be prepared in a very short time, and at very little cost beyond that of the creosote.

If very dry timber, such as that referred to above, were used without previous preparation, it would be liable to rot very quickly when buried.

Elm and beech, when green, serve excellently as stay blocks. for when buried in that state they last for an indefinite period. Outer slabs or tem-

porary sleepers of this material can occasionally be obtained very cheaply at saw mills where this timber is cut up.

MATERIALS FOR UNDERGROUND TELEGRAPHS.

Copper, on account of its high conductivity, is the metal used for the conductor in all underground work. Various insulating media have been suggested and experimented with, but guttapercha and indiarubber alone have to any considerable extent been employed, and the former is that almost exclusively used in England.

Under proper treatment, and in favourable circumstances, the durability of guttapercha is very great, but when exposed to light and air it deteriorates very rapidly through oxidation, losing its elasticity, assuming a resin-like form, cracking throughout, and its insulating powers becoming rapidly less and less. When, however, protected from the admission of light and immersed in water there is, if the material be of good manufacture, scarcely a known limit to its life, as under such circumstances it appears practically indestructible.

In the manufacture of guttapercha, the crude material is first subjected to various processes by which the impurities mixed with it, in collection or transit, are eliminated. It is then partially liquified or rather much softened by heat, and applied to the conductor by being forced through a die. To diminish the possibility of defects in the covering, it is generally laid on in separate coatings, the minimum being two of guttapercha and two of a material termed Chatterton's compound, a composition of guttapercha, resin, and Stockholm tar. This composition effects a perfect union between the various coatings of guttapercha, and between these and the conductor.

Ordinary copper wire has a tensile strength of 60,000 lbs. per square inch, but that used for telegraphic purposes, being selected more with a view to its electrical than its mechanical qualities, varies from 35,000 lbs. to 39,000 lbs. only. Guttapercha has a tensile strength of about 3,500 lbs. per square inch, but owing to its great extensibility, it does not add more than one-third its whole strength to the complete wire. It begins to elongate with a strain of about 6 cwt. per square inch.

Jenkin gives (Cantor lectures) the following approximate formulæ for the mechanical strength of copper wire :—

"A copper strand will bear $1\frac{1}{2}$ lbs. per pound weight per knot before breaking. It will stretch 1 per cent. with 1 lb., and will not stretch at all with 0·75 lbs. weight per pound per knot."

Extending this to the guttapercha, on the basis of the figures quoted above, it would appear that the latter adds a little over half a pound additional useful strength for each pound weight of guttapercha, and that it will commence elongating with rather less than a quarter pound for each pound weight of material per nautical mile. These considerations are of value in dealing with underground work, which is frequently exposed to considerable strains, under the method of laying it which obtains in this ountry.

Formerly, in England, a conductor of No. 16 B. W. gauge, covered with guttapercha to a thickness indicated by Nos. 3 or 4 B. W. G., was in general use for underground telegraphs. For some past years, however, the improvement in the conductivity of copper used for telegraphic purposes, and the success with which the endeavours to increase the insulating properties of guttapercha have been crowned, have enabled manufacturers to issue a wire, having the same electrical qualities, and occupying much less space. Thus a conductor with a gauge of No. 18, covered to No. 7 B. W. G. with guttapercha, is equal electrically to the wire formerly in use, although containing but half the weight of the insulating material, with the further advantage that a much larger number of wires can be drawn through a given size pipe or conduit. On the other hand, it should be noted that the mechanical qualities are diminished by the decrease in size, both the strength of the wire being less, and the insulating coating being more readily damaged, by any cause which might have been insufficient to bare the conductor with a thicker coating. In specifications for G. P. wire, the gauges of the conductor and insulator respectively should be clearly laid down, in decimals of an inch, together with the conductivity of the copper in terms of pure metal. The latter is generally taken at 100, and inasmuch as some specimens of copper have a conductivity of 27 only, as compared with this standard, it is evident how necessary it is to agree on a minimum result. Some cable wires have as high a conductivity as 96·8 per cent., but for underground work 90 to 92 may be taken as a minimum. The wire should be carefully tested in water, and a minimum insulation of 200 to 250 megohms per mile, at a temperature of 75 degrees Farenheit, should be stipulated for in the case of wire of the dimensions referred to above. The wire before use should be covered with a layer of tape, saturated with Stockholm tar, and wound on spirally, to protect the guttapercha. Stockholm tar is not an insulator, in fact it is well known that it diminishes the insulating capacity of the guttapercha to which it is applied, but it more than counterbalances this, in protecting the gum from the injurious effects of the atmosphere, from which it would otherwise suffer.

To protect the insulated wire grooved boarding was at one period extensively used, either plain or creosoted, in some cases with separate grooves for each wire, and sometimes with one large groove for several wires. Except for leading wires into and through buildings and tunnels, this form of protection has been abandoned, and in the latter cases it is now generally constructed in the form of a rectangular box, of the size necessary to carry any given number of wires thought neceesary. Ordinary Baltic or pitch pine boarding is planed, cut to size, three of the sides of the rectangular box are nailed together, the fourth or lid being either screwed down or attached by means of a wire; or a rectangular trough may be ploughed out of a solid piece of quartering by means of suitable machinery. This is perhaps preferable when the boxing is not intended for many wires, as in this case a circular or other agreeable moulded form can be readily given to the outer portion of the case.

Creosoted timber should not be used, as creosote affects the G.P. injuriously, neither should coal tar be allowed to come in contact with the latter for a like reason. If coal tar be used for preserving the casing it should only be applied outwardly. For underground work, pipes either iron or earthen-

ware, are now used, the former being invariably employed in towns, the latter frequently in the country. Formerly iron pipes, slit throughout longitudinally, the upper portion forming a lid, were much employed, the lower half being laid in an open trench, and the cover placed on after the cables had been laid into it, but in this country ordinary gas or water-pipes have entirely superseded the split form, in consequence of the impossibility of withdrawing cables from the latter for repairs, &c., without reopening the ground throughout. The iron pipes now used for main lines are generally three inches in diameter, of a good quality of cast-iron, each measuring nine feet, provided with a socket, and weighing about 100 lbs. The pipes should be cleanly cast, and free from jagged edges and other imperfections in the interior, which would tend to injure the insulating covering of the wire. For light lines pipes of a lesser diameter, either of cast or wrought-iron, can be used.

Where mechanical injury is not anticipated, such as in country roads, earthenware pipes are very effective, and much cheaper than iron ones. These are usually two and a half to three feet long and provided with a socket. They should be straight, clean, free from irregularities, and well burnt and glazed.

Test boxes, placed at regular intervals for convenience of drawing in the cables, testing, &c., are generally of two forms. In towns where the pipes are laid under the paved footway, rectangular iron boxes, with covers formed of a flagstone to correspond with the paved way, are employed, the top of the box being level with the footpath. Two sizes are generally used, according to the number of wires in the pipes, one being 28 inches long by $9\frac{3}{4}$ inches wide, with a depth of 12 inches, and the other 32 inches long by 13 inches wide.

Where the pipes are under the cartway, the boxes are kept below the level of the metalled road, and an iron cover is used in lieu of the stone one. Sufficient strength should be given to this cover, and it should be placed at an adequate depth to resist the crushing effect of steam road-rollers in towns where these are used.

(To be Continued.)

Notes.

We understand that the Submarine Company's cable, between Dover and Calais, is interrupted.

The Indian Government has announced its intention of joining the International Postal Union

A telegraph cable is to be laid between the Admiral's Office at Queenstown, and the yard and hospital at Haulbowline.

The Great Northern Telegraph Company announce that communication is restored through their China and Japan cable.

The traffic receipts of the Direct Spanish Telegraph Company for the month of November, 1875, were £1,697 16s. 10d., against £1,224 10s. in the corresponding period of last year.

The average time occupied in the transmission of telegrams between Madrid and England, "viâ Santander," during November, was 2 hours 25 minutes (including transmission over Spanish land lines).

Both the Western Union and the Atlantic and Pacific Telegraph Companies have asked for permission to lay down pneumatic tubes in New York. The former also contemplates placing their town wires underground.

The number of messages passing over the lines of the Cuba Submarine Telegraph Company during the month of November, was 2,520, estimated to produce £2,500, against 1,621 messages, producing £1,904 in the corresponding month of last year.

The *St. Martin's Magazine*, which is produced and supported by members of the Postal Telegraph Service, is publishing a series of photographs of eminent men in the service. The following have already appeared:—Lord John Manners, Messrs. Scudamore, Baines, and Fischer. They are very well done, and form quite a new feature in telegraphic literature.

We learn from the Argentine Republic, from Buenos Ayres, that the construction of a short land line, to complete the communication from Buenos Ayres, has been concluded. Martin Garcia is an island in the centre of the River Plate, where it is formed by the confluence of the River Parana and Uruguay. The cable (26 miles in length) had been sent out for torpedo purposes; it consists of one wire, and is laid between Martin Garcia and San Isidio, whence to Buenos Ayres is 15 miles of land line.

We have been favoured with some copies of the Indian *Telegraphic Journal*, a bi-monthly magazine of electrical science. It is printed at Lahore, and circulates amongst the operating department of the Indian Government telegraphs. It contains questions and papers on elementary mathematics and on the elements of magnetism and electricity, and it indicates a healthy desire for improvement in that large class of telegraphists.

With regard to the interruption of the Eastern Company's cable, and a short interruption in the Indo-European route, Major J. U. Bateman-Champain, R.E., Director-in-Chief Indo-European Government 55, Parliament-street, writes:—"The Eastern Company's cable is at present disabled near Aden. A few days ago an interruption of some hours duration (caused by violent storms in the neighbourhood of Kertch) occurred on the Indo-European Company's line, and communication with India was very generally supposed to be altogether suspended. It seems right, therefore,

for me to remind the public of the existence of a third separate telegraphic route between England and India, viz., that by Constantinople, Bagdad, and the Persian Gulf. So soon as I was informed of the break on the Indo-European Company's line, I despatched an urgent telegram to the Indian Director-General at Calcutta. My message, directed 'viâ Turkey,' occupied 15 hours 39 minutes in transmission, while the reply from Calcutta to London took 4 hours 38 minutes. I am officially informed by the Ottoman Telegraph authorities that the line from the Persian Gulf through Constantinople and by Valona to England is in satisfactory order, and that every care is taken to ensure the rapid transmission of Indian messages. In fact the three lines to India, viâ Teheran, viâ Turkey, and viâ Suez, have never since their establishment been simultaneously interrupted, and in the interests of the public and the press I beg the favour of your inserting these explanatory remarks in your journal.'

The following sweeping alteration has been made in the mode of signalling telegrams in the Postal Telegraph Department—

1 (a). *Inland Telegrams.*—The number of words in the *text* of the message only is to be counted and signalled. The words in the addresses and instructions, which have hitherto been counted, will thus be excluded from the number signalled.

1 (b). *Foreign Telegrams.*—In foreign telegrams the number of chargeable words only is to be counted and signalled.

2. The charges collected on foreign telegrams are not to be signalled.

3. The word "From," standing before the address of the sender, is not to be signalled.

4. Instead of signalling the word "To," the separation between the address of the sender and of the receiver of the message is to be made by means of the signal - - - - - (i i).

5. The signal DQ is to be replaced by the signal - - - - (i i).

6. The signal MM is to be abolished, and the Office of Origin, and instructions (if any), are to be signalled *after the code time*, instead of, as at present, after the text of the message.

7. The signal RT, which has hitherto preceded the acknowledgment, is no longer to be used, but the name of the addressee is to be repeated without any preliminary signal.

Under these alterations the order of signalling a telegram will be as follows:—

The prefix S (or X).

The Code Time.

The Office of Origin, and instructions (if any).

The number of words in the *text.* (In foreign telegrams the number of chargeable words).

The name and address of the sender of the message.

The break signal - - - -

The name and address of the receiver of the message.

The break signal - - - -

The text of the message.

The signal - - - — - denoting the completion of the message.

The Receiving Clerk will then give the acknowledgment, i.e.,—

The name of the addressee, followed by the repetition of figures and doubtful (if any) and the signal - - - — -

The effect will be to reduce considerably the number of service signals, and thereby to increase the capacity of wires for the transmission of messages.

Proceedings of Societies.

THE SOCIETY OF TELEGRAPH ENGINEERS.

The following is an abstract of a paper read "On Cable-Borers," by G. E. Preece.*

The first appearance of any damage done to a submarine cable appeared to the Levant cable, laid by Mr. Newall, who speaks of the destruction of the hemp by a species of 'teredo.' Mr. Siemens speaks to the same effect, and says, 'This cable, which was laid in 1858, and taken up again last summer (1859), was found to be beset by another enemy in the shape of millions of small shell-fish or snails, accompanied by small worms, which had completely destroyed the unsheathed hemp, and eaten some circular holes in the gutta-percha.' Professor Huxley wrote as the result of his examination of these shells: "The specimens you sent me remove all doubt as to the nature of the mischief-maker in the cable. It is a bivalve shell-fish, the xylophaga, closely allied to the ship-worm (teredo), but distinguished from it, among other peculiarities, by not lining its burrow with shelly matter. The zylophaga turns beautifully cylindrical burrows, always against the grain, in wood; and I have no doubt it perforated the hempen coating of the cable in the same way. On meeting the gutta percha it seemed not to have liked it, and to have turned aside, thus giving rise to the elongated grooves which we see. Nothing is known, so far as I am aware, of the range in depth of zylophaga, so that I cannot answer your enquiry as to whether it is probable that cables immersed in 600 to 2,000 fathoms of water would be attacked or not."

In 1860, several portions of cable covered with hemp and steel wire were picked up in the Mediterranean off Minorca; these were found in places, and up to deep water, very much attacked by

* Read at the Meeting, 24th November. See page 279.

xylophaga. The hemp between the steel wires being eaten away into holes with the regularity and spacing of those in a cribbage-board. As in previous cases the guttapercha was penetrated to various depths, but not more than the size of the shell-fish. It was generally considered that the xylophaga did not penetrate, owing to its dislike to guttapercha; but some persons at the time, thought there was a great deal of doubt upon the point, for there was no sign amongst the great length of cable so damaged, of any dislike, the main sign being that there had been *no time* for further penetration.

Subsequently some specimens were forwarded from Norway, giving the usual marks of a borer.

These marks have been noticed in many of the cables in the English Channel, and the French Atlantic cable off Brest, and the Anglo-American off Valentia bear similar marks.

In the repairs lately executed to the Key West and Punta Rasa cable the teredo was again visible, and it may be assumed that various kinds of borers may be met with all over the world.

Round the English coast there is a small borer which, where it can get at the cable, penetrates direct to the conductor, and produces a fault. In the cables across the Irish Sea, to Wexford and Dublin, these "borers" have been met, but on the Welsh side.

During some repairs to the Holyhead-Dublin cable, it was noticed that "at about six miles from Port Crugmor (the landing-place), at every broken wire and open place in the sheath, all the inner hemp serving is completely eaten away by worms, leaving the percha core exposed, which in one or two places is scored from the same cause."

At other points the guttapercha was found pierced directly inwards, and a small worm found in each hole. At the same spot the hemp was found eaten away, and two or three different varieties of worms were noticed. Fortunately some specimens of these were obtained and preserved in spirit. When they were brought to London Mr. Culley, of the General Post Office, forwarded some specimens to Dr. Carpenter, F.R.S., a gentleman well known for his investigation into marine life, for examination and report.

Sir,—I exceedingly regret the delay which has occurred in my reply to your communication of the 27th November last, with reference to the marine animals by which the Telegraph Cables are attacked.

Had I relied on my own judgment alone, I should have been able to answer you at once, and thought that I recognized all your specimens as types with which my marine researches have made me familiar.

But in a matter of such importance I judged it better to obtain a corroboration or correction of my own judgment from the naturalists who rank as the highest authorities in this country on (1) marine worms, and (2) crustaceans.

Dr. Mackintosh, who is now bringing out a complete work on the marine worms of Great Britain, and who is extremely conversant with their habits as well as with their form and structure, recognizes three types, *Lepidonotus equamatis*, *Evarne impar*, and *Nereis pelagica*, all well known British forms; and says, "I agree with you in acquitting them of all share in making the perforations in the coverings of the cable. They had only been lurking (after their wont) in the holes made by other forms."

The Rev. William Norman (whose letter I only received this morning), agrees with me in identifying the minute crustacean as the *Limnoria lignorum* of Rathké, known to British naturalists as the *Limnoria terebrans*. This is a most destructive creature, whose ravages have long been a source of great injury to the wood work of piers, bridges, harbour works, &c., often erroneously attributed to the borings of the teredo, a full description of its structure and habits was given by Dr. Coldstream in the Edinburgh New Philosophical Journal, vol. xvi, p. 316.

Clearly, therefore, it is the *Limnoria* that does the mischief to your cables. As its ravages were long ago noticed at Dublin, it must be an old inhabitant of the Irish sea. It is so small a creature that it would easily make its way through any fissure left by the separation of the wires of the iron sheathing; and it would seem to me that the overlapping copper riband of Messrs. Siemens would afford a surer protection.

Trusting that this report will be satisfactory to you,

I remain,
Your obedient Servant,
(Signed) Wm. B. Carpenter.

R. S. Culley, Esq.

The annual general meeting was held on Wednesday, the 8th December; Mr. Latimer Clark, President, in the Chair.

The names of twelve new candidates were announced.

The Council reported that they had transferred Mr. Walter Hancock to the class of Member.

The Secretary then read the report of the President and Council for the year 1875, of which the following is an abstract:—

Attention was drawn to the kindness of the Institution of Civil Engineers in allowing the Society to use their theatre for the meeting, and to whom the thanks of the Society were largely due.

The numerical progress of the Society was satisfactory, the increase during the year being 115 members of all classes; foreign members, 41; members, 25; associates, 47; students, 2. The increase being particularly striking as regards foreign members, the increase in the previous year being 126 members of all classes.

The total number of members of all classes amounted to 763, against 648 of 1874, and consisted of honorary members, 4; foreign members, 122; members, 227; associates, 393; students, 17; total, 763.

Allusion was made to the death of Mr. Carl Becker, and also to Sir Charles Wheatstone. The report gave further a resumé of the meeting during the past year, and of the work done. It was announced that the Council had arranged for the publication of the Journal quarterly, and it was proposed that in future the ballot should be taken monthly only.

It was announced that the Ronald's Library was in progress of arrangement, and that the printing of the catalogue was being pushed forward.

The ballot for the election of President and

Officers for the year 1876 was then taken with the following result:—

President—C. V. Walker, F.R.S.

Vice-Presidents—Professor Abel, F.R.S.; Major Bateman-Champain, R.E.; R. S. Culley, C.E.; Professor Foster, F.R.S.

Members of Council—Professor W. G. Adams, F.R.S.; H. G. Erichsen; Edward Graves; Colonel Glover, R.E.; Charles Hockin, C.E.; Major Malcolm, R.E., W. H. Preece, C.E.; Robert Sabine, C.E.; Carl Siemens, C.E.; C. E. Spagnoletti, C.E.; Lieut.-Col. Stotherd, R.E.; Cromwell F. Varley, F.R.S.

Associates—O. Heaviside, J. Sivewright, M.A., W. J. Tyler.

Hon. Treasurer—Major Webber, R.E.

Hon. Secretary—Major Frank Bolton.

A paper was read on "Underground Telegraphs—The London Street Work," by Charles Fleetwood, an abstract of which will appear in our next.

The following candidates were balloted for and duly elected:—

Foreign Members—L. Arisz, the Hague; C. Brieve, ditto; Hugh Nielson, Toronto, Canada; Don Antonio Oloriz, Santander.

Members—John Ahern, Manchester; John F. H. Betts, London; Walter C Johnson, Charlton.

Associates — E, Castle, the Temple; George Dubern, India Government Telegraphs; George W, Hook, Post Office Telegraphs; Walter Judd, Eastern Extension Telegraph Company; John J. Payn, Eastern Telegraph Company; James J. Philpott, Postal Telegraphs; William N. Tiddy, School of Telegraphy; R. A. Warner, Buenos Aires; Horatio Yeates, London.

Sergeant-Major W. Turner, R.E.; Sergeant-Major John Ross, R.E.; Sergeant E. Morrison, R.E.; Sergeant E. Emms, R.E.; Sergeant J. Oldershaw, R.E.; Corporal A. Richards, R.E.; Corporal F. Kenney, R.E.

The meeting then adjourned.

INTERNATIONAL EXHIBITION OF ELECTRICAL APPLIANCES TO BE HELD AT PARIS IN 1877.

An International exhibition of electrical sciences will be held at the Palais de l'Industrie at Paris in 1877. This exhibition will last four months.

The various objects to be exhibited have been divided into 18 classes, under the following heads:—

Class 1.—The history of electricity, the earliest discoveries, primitive instruments and apparatus, instruments of the principal inventors and first masters.

Class 2.—Educational apparatus, instruments for use in physical laboratories for the demonstration of Static and Dynamic electricity.

Class 3.—Generators of electricity, Batteries, instruments for the production of currents, induction machines, raw and manufactured material used for the production of electricity.

Class 4.—Electro magnetism, the electro magnet, its uses, effects, and stages of manufacture; magneto electric machines.

Class 5.—Electric telegraph, electric wires and cables, bells, signals, transmitting and receiving apparatus, sounders, dial instruments, embossers, writers, &c., domestic telegraphy.

Class 6.—Electric clockwork, clocks, regulators, chronometrical receivers, chronoscopes, and chronographs.

Class 7.—Railways, warning and protection signals, block signals, and electric brakes.

Class 8.—Electric motors, electric engines, revolution indicators, warning apparatus in workshops and manufactories, mechanical application of electricity for domestic purposes.

Class 9.—Electric light, lighting of towns, manufactories, lighthouses, subterranean and submarine lights, instantaneous lighting application to photography.

Class 10.—Electro chemistry, chemical action of electricity, electro metallurgy, organic synthesis and analysis.

Class 11.—Electroplating, application of electro chemistry to fine arts, gilding, silvering, nickelisation, coppering, &c.; reproduction of medals, statues, bas-reliefs, &c.

Class 12.—Electrotyping, the application of electricity to printing and engraving, electrotyped cliches, electro chemical engraving, engraving machines.

Class 13.—Medical electricity, application of electricity to physiology, therapeutics and surgery, baths, brushes, galvanic chains, galvano caustics.

Class 14.—Meteorological electricity, thunderstorms, lightning protectors, earth currents, compasses, observatory apparatus.

Class 15.—Military art, special telegraphy, artillery engineering, surveying.

Class 16.—Marine, signals of command and distress, submarine defence and attack torpedos, marine compasses, nautical soundings.

Class 17.—Various applications, electric trinkets, application of electricity to conjuring and phantasmagoria, electric toys.

Class 18.—Bibliography, catalogued and indexed collection of all works, French and foreign, bearing on practical or theoretical electricity.

INVIOLABILITY OF TELEGRAPH MESSAGES.

The prosecution instituted against a Newry shipbroker, for inducing a telegraph clerk, by pecuniary bribes, to give him information respecting the arrival of foreign vessels, has excited, from its novelty, considerable attention. From what transpired before the Newry Bench on Monday, it seems that the accused, who occupied a respectable position as a general grocer as well as shipbroker, put himself in communication with a telegraph clerk named Whittaker, with the object of inducing him to intercept and disclose certain messages. After some time the boy was indnced to enter upon this very dishonest and dangerous course for a consideration of half-a-crown for every message disclosed. Because of some complaints made to the local Postmaster, suspicions were excited, and the collusion between the clerk and shipbroker detected. The former was summarily dismissed, and a prosecution entered against the latter for inducing Whittaker to commit a misdemeanor. The prisoner was committed for trial at the Downpatrick Assizes, bail being accepted for his appearance. It is only right and proper that the Post Office authorities should take the most stringent

measures against the persons implicated in these proceedings. Telegraph officials are entrusted with a highly responsible duty. In point of fact nearly every man who sends away a message makes them his confidants. Upon their strict honesty and trustworthiness a great deal often depends. If confidence were once shaken in the integrity of telegraph officials the usefulness of the system would be in a great measure destroyed. The inviolability of a message is not to be outraged with impunity, if at all possible, in even a single case. Hence we view with satisfaction the steps which the Post Office authorities have taken. The fact that the Newry prosecution is the first that has been instituted, at least in Ireland, under an act passed for the protection of the senders and receivers of telegrams, shows unmistakably how trustworthy the officials, as a body, are. It is conclusive testimony of the efficient and faithful manner in which they perform their duties. Nothing could be more creditable to the body than the fact that the Newry prosecution has been the first. For the sake of all parties let us trust it will be the last.—*The Derry (Ireland) Journal.*

THE BAKERIAN LECTURE.

An Account of several new Instruments and Processes for determining the Constants of a Voltaic Circuit.

By CHARLES WHEATSTONE, Esq., F.R.S.,

Professor of Experimental Philosophy in King's College, London, Corresponding Member of the Academy of Sciences at Paris, &c.

Received June 15.—Read June 15, 1843.

SECTION 1.—I intend in the present communication to give an account of various instruments and processes which I have devised and employed during several years past for the purpose of investigating the laws of electric currents. The practical object to which my attention has been principally directed, and for which these instruments were originally constructed, was to ascertain the most advantageous conditions for the production of electric effects through circuits of great extent, in order to determine the practicability of communicating signals by means of electric currents to more considerable distances than had hitherto been attempted. In this endeavour, guided by the theory of Ohm and assisted by the instruments I am about to describe, I have completely succeeded. But the use of the new instruments is not limited to this especial object; they will, I trust, be found of great assistance in all inquiries relating to the laws of electric currents, and to the various and daily increasing practical applications of this wonderful agent. An energetic source of light, of heat, of chemical action and of mechanical power, we only require to know the conditions under which its various effects may be most economically and energetically manifested, to enable us to determine whether the high expectations formed in many quarters of some of these applications are founded on reasonable hope, or on fallacious conjecture. The theory we now possess is amply sufficient to direct us rightly in this inquiry, but experiments have not yet been sufficiently multiplied to enable us to obtain, except in a few cases, the numerical values of the constants which enter into various voltaic circuits; and without this knowledge we can arrive at no accurate conclusions.

Section 2.—The instruments and processes I am about to describe being all founded on the principles established by Ohm in his theory of the voltaic circuit, and this beautiful and comprehensive theory being not yet generally understood and admitted, even by many persons engaged in original research, I could scarcely hope to make my descriptions and explanations understood without prefacing them with a short account of the principal results which have been deduced from it. It will soon be perceived how the clear ideas of electro-motive forces and resistances, substituted for the vague notions of intensity and quantity which have been so long prevalent, enable us to give satisfactory explanations of most important phenomena, the laws of which have hitherto been involved in obscurity and doubt. Viewing the laws of the electric circuit from the point at which the labours of Ohm has placed us, there is scarcely any branch of experimental science in which so many and such various phenomena are expressed by formulæ of such simplicity and generality; in most of the physical sciences the facts of observation and experiment have kept pace with theoretical generalization, in this science alone they had gone on accumulating in prolific abundance without any successful attempt having been made to reduce them to mathematical expression. But this is now happily effected, and what has hitherto been mere matter of speculative conjecture is removed into the domain of positive philosophy.

By *electro-motive force* is meant the cause which in a closed circuit originates an electric current, or in an unclosed one gives rise to an electroscopic tension. By *resistance* is signified the obstacle opposed to the passage of the electric current by the bodies through which it has to pass; it is the inverse of what is usually called their conducting power.

When the activity of any portion of the circuit is increased or diminished, either by a change in the electro-motive force or in the resistance of that portion, the activity of all the other parts of the circuit increases or decreases in a corresponding degree, so that the same quantity of electricity always passes in the same instant of time through every transverse section of the circuit.

The force of the current is directly proportional to the sum of the electro-motive forces which are active in the circuit, and inversely proportional to the total resistance of all its parts, or in other words the force of the current is equal to the sum of the electro-motive forces divided by the sum of the resistances.

Let F denote the force of the current, E the electro-motive forces, and R the resistances: then

$$F = \frac{E}{R}.$$

The length of a copper wire of a given thickness, the resistance of which is equivalent to the sum of the resistance in a circuit, Ohm calls a *reduced length*, an expression which it will frequently be found convenient to employ.

If the electro-motive forces and resistances in a

circuit are proportionately increased or diminished the force of the current remains the same, or

$$\frac{E}{R} = \frac{n\,E}{n\,R}.$$

Hence a single voltaic element, or a battery consisting of any number of exactly similar elements, if no additional resistance be interposed in the circuit, produces the same effect. Also a thermo-electric element and a voltaic element will produce the same effect when the greatly inferior electro-motive force of the former is compensated by a corresponding decrease in its resistance; in a thermo-electric arrangement the resistance is in general small, because the circuit is entirely metallic, while in a voltaic element the resistance of the liquid is always considerable.

Any interposed resistance weakens the force of the current, but less so as it is smaller in proportion to the other resistances in the circuit. Hence in two circuits, both producing currents of equal force, when the same resistance is introduced, the strength of the two currents may be weakened in very different proportions. A single voltaic element, $\frac{E}{R}$, and a series consisting of any number of such elements, $\frac{n\,E}{n\,R}$, form circuits in which the currents have the same force, but very different results will be obtained according as the added resistance is great or small compared with the original resistances in the circuits; if it be small, the effects of the two circuits will remain sensibly the same; but if it be large, the resistance that weakens to a very great extent the current in the circuit of the single element produces but a trifling diminution in that of the series. This explains the necessity of employing a series to overcome considerable resistances. The same remarks will apply to the comparison of a thermo-electric with a voltaic circuit.

The following is the general formula for the force of the current in a voltaic circuit when completed by a connecting wire; the metallic plates of the voltaic elements being parallel to each other and of equal size:—

$$F = \frac{n\,E}{\frac{n\,R\,D}{S} + \frac{r\,l}{s}}.$$

F is the force of the current, E the electro-motive force of a single element, n the number of elements, R the specific resistance of the liquid, D the thickness ot the liquid stratum or distance of the plates, S the section of the plates in contact with the liquid, r the specific resistance of the connecting wire, l its length, s its section.

Expressed in words we have the following laws:—

The electro-motive ferce of a voltaic circuit varies with the number of the elements, and the nature of the metals and liquids which constitute each element, but is in no degree dependent on the dimensions of any of their parts.

The resistance of each element is directly proportional to the distance of the plates from each other in the liquid, and to the specific resistance of theli quid, and is also inversely proportional to the surface of the plates in contact with the liquid.

The resistance of the connecting wire of the circuit is directly proportional to its length and to its specific resistance, and inversely proportional to its section.

The limits of this communication will not allow me to dwell longer on the consequences of Ohm's theory of the electric circuit; for further developments I must refer to the author's work, 'Die Galvanische Kette mathematisch bearbeitet,' Berlin, 1827, a translation of which has appeared in Taylor's Scientific Memoirs, vol. ii.; to his various other memoirs published in Schweigger's 'Jahrbuch der Physik;' and to the more recent applications of the theory made by Fechner, Lenz, Jacobi, Poggendorff, Pouillet, &c.

There is, however, one class of considerations which it is indispensable I should bring forward, because upon it are founded many of the instruments and processes which I shall have occasion hereafter to mention,—I allude to the laws of the distribution of the electric current in the various parts of a circuit, when a branch conductor is placed to divert a portion of the current from a limited extent thereof.

Let λ be the reduced length of the portion of the circuit from which the current is partially diverted, λ' that of the wire which diverts the current, and L that of the undivided part of the circuit. The force of the current in each of the adjacent conductors, λ and λ', can be shown to be in the inverse ratio of their reduced lengths, and the reduced length of a single wire, which, substituted for both, would not alter the force of the current, to be $\frac{\lambda\lambda'}{\lambda + \lambda'}$, which we will designate by Λ.

The force of the current in the original circuit before the introduction of the branch wire will then be expressed thus:—

$$F = \frac{E}{L + \lambda},$$

and the strength of the current in the three different portions of the altered circuit by the following expressions:—

In the principal or undivided portion L,

$$F_1 = \frac{E}{L + \Lambda} = \frac{E\,(\lambda + \lambda')}{L\,(\lambda + \lambda')\,\lambda\lambda'}$$

In the portion from which the current has been partially diverted, or λ

$$F_2 = \frac{E}{L + \Lambda} \cdot \frac{\Lambda}{\lambda} = \frac{E\lambda'}{L\,(\lambda + \lambda') + \lambda\lambda'}$$

In the portion which partially diverts the current, or λ',

$$F_3 = \frac{E}{L + \Lambda} \cdot \frac{\Lambda}{\lambda'} = \frac{E\lambda}{L\,(\lambda + \lambda') + \lambda\lambda'}$$

Section 3.—It is seldom that any real advance is made in a scientific theory without a corresponding change in its terminology being required. Now that it is proved beyond doubt that the various sources of continued electric action differ from each other only in the amount of their electro-motive forces, modified by the resistance of the circuit of which they form part, it becomes of importance, in order to give precision to our statements and to avoid circumlocutions otherwise inevitable, to adopt general terms to express the source of a current without reference to the peculiar mode of its production; I shall therefore employ the word *Rheomotor* to denote any apparatus

which originates an electric current, whether it be a voltaic element or a voltaic battery, a thermo-electric element or a thermo-electric battery, or any other source whatever of an electric current; when speaking of a single element I shall term it a rheomotive element, and what is usually called a voltaic or thermo-electric pile or battery I shall term a rheomotive series. I shall still use the ordinary expressions when I have to refer to the specific sources of the production of electric currents, and when I employ the essential terms they must be understood to apply to all these sources indifferently.

The want of a general term to designate an instrument to measure the force of an electric current without reference to its particular construction has been long felt. I shall use the word *Rheometer* for this purpose, continuing occasionally to employ galvanometer, voltameter, &c., to distinguish the particular instruments to which these names have been applied, though perhaps the terms Magnetic, Chemical, Calorific, &c. Rheometer would be more appropriate.

This may be a proper place to explain a few other terms which I have frequent occasion to use, though not in the course of the present communication. By *Rheotome* is meant an instrument which periodically interrupts a current, and by *Rheotrope* an instrument which alternately inverts it. A *Rheoscope* is an instrument for ascertaining merely the existence of an electric current. The word *Rheostat* will be hereafter explained.

I have not introduced these terms, which will be found greatly convenient and will enable us to state general propositions much more clearly, without good authority. The word Rheophore was employed by Ampère to designate the connecting wire of a voltaic apparatus, as being the carrier or transmitter of the current; and the word Rheometer, first proposed by Peclet as a synonym for galvanometer, has been generally adopted by the French writers on physics.

Section 4.—The method of obtaining the constants of a rheophoric circuit adopted by Fechner, Lenz, Pouillet, &c., in their experimental verifications of Ohm's theory, is essentially the following:—

The resistance of a circuit is determined by observing the force of the current, first without any extra interposed resistance in the circuit, and afterwards when a known resistance is added. Then

$$F = \frac{E}{R}, \text{ and } F' = \frac{E}{R + r} \therefore \frac{F}{F'} = \frac{R + r}{R},$$

from which equation the value of R, all the others being known quantities, is easily deducted.

$$R = \frac{F'}{F - F'} r.$$

The electro-motive force of a circuit is ascertained by multiplying the force of the current into the total resistance; for since

$$F = \frac{E}{R} \therefore E = FR.$$

The principle of this method is extremely simple, but the difficulty of determining immediately the force of the current by means of a galvanometer is an obstacle to its general employment. Fechner measured the force of the current by the number of oscillations of the needle when placed at right angles to the coils, a very tedious operation; and others have employed the deviations of the needle, the corresponding degrees of force having been previously determined by some peculiar process, or inferred from some rule depending on the particular construction of the instrument. Another impediment to the use of a galvanometer to measure the force of a current arises from the changes in the magnetic intensity of the needle which frequently occur, especially when it has been acted upon by too strong a current.

The principle of my method is that of employing variable instead of constant resistances, bringing thereby the currents in the circuits compared to equality, and inferring from the amount of the resistance measured out between two deviations of the needle, the electro-motive forces and resistances of the circuit according to the particular conditions of the experiment. This method requires no knowledge of the forces corresponding to different deviations of the needle.

To apply this principle it is requisite to have a means of varying the interposed resistance, so that it may be gradually changed within any required limits. I have contrived two instruments for effecting this purpose, one intended for circuits in which the resistance is considerable, the other for circuits where the resistance is small.†

(To be Continued.)

* Massbestimmungen über die Galvanische Kette. Leipzig' 1831, p. 5.

† It appears that the idea of constructing an instrument of this kind had also occurred to Professor Jacobi of St Petersburg. When I explained to this eminent experimentalist my instruments and processes in the beginning of August, 1840, he informed me that he had himself constructed a similar instrument which he had exhibited to the Academy of Sciences at St. Petersburg, though no description of it had yet been published, and he at the same time showed me a drawing of it. This instrument, which he has since called an Agometer, differs in mechanical construction from either of mine, and is less convenient to manipulate; but its principle is the same. In a communication which Professor Jacobi made in the following month to the Meeting of the British Association at Glasgow, and which was published in the Athenæum of No. 678, 1840, he thus alludes to the subject:—

"Before proceeding, I may be permitted to make some remarks concerning an instrument which I laid before the Academy of Sciences in the commencement of this year. It is destined to regulate the galvanic current, and is of value in many investigations of this kind. During my sojourn in London, Professor Wheatstone has shown me an instrument, founded exactly on the same principles as mine, and with very insignificant modifications and differences. Now, it is quite impossible that he should have had the least notice of my instrument; but as it is probable that its use may be greatly extended, I must add, that while I have only used this instrument for regulating the force of the currents, he has founded upon it a new method of measuring these currents, and of determining the different elements or constants which enter into the analytical expressions, and on which depends the action of any galvanic combination. It is principally to the measure of the electro-motive force, by those means, that Mr. Wheatstone has directed his attention; and he has shown me, in his unpublished papers, very valuable results which he has obtained by this method."

Professor Jacobi has since his return employed my method of determining the constants of a voltaic circuit. The memoirs in which his results were given were republished in Poggendorff's "Annalen der Physik," vol. liv. No. 2 for 1841, and vol. lxii. No. 9, for 1842. To the latter the learned editor, who has made most valuable researches himself in the same path, has appended (p. 89) the following note:—"I will take this opportunity to call to mind that I applied the same method (or at least one identical to it in principle) before it was communicated to the author by Mr. Wheatstone. See the Annals, vol. lii. p. 526." I have referred to this volume and find that it was published in the latter part of 1841, while my communication to Professor Jacobi was, as above stated, made in August, 1840. I may also mention, that the experimental process employed by Professor Poggendorff had no resemblance whatever to mine, and the result he sought was likewise different; the mathematical principle of the method was however in the single case he investigated undoubtedly the same.

SIEMENS' AUTOMATIC CYLINDER TRANSMITTER.

THIS instrument unites the two functions, of composing and transmitting messages automatically by means of a *single* apparatus of comparatively small dimensions.

These two functions are independent of each other, although both are being carried on at the same time; the apparatus being thus distinguished from other automatic instruments by *not* requiring *two* different portions for composing the message (generally by means of perforated paper) and transmitting the same.

The Cylinder Transmitter is brought into the direct circuit of the line, and the sending of a message is caused by pressing down finger-keys, each of which corresponds to a letter, number, or mark of punctuation, which is written on the knob of the key.

The rapidity with which these finger-keys may be worked depends upon the velocity of the revolving cylinder, the speed of which is independent of the working of the finger-keys.

The message received is in Morse signals, but the difference in the length of these signals does not depend upon the time the finger-keys are held down, as the signals and spaces always appear of their normal length, whether the manipulator occupies more or less time between the pressing down of two following keys; the blank spaces between two words are produced by a special key called the "blank key."

In order that the instrument may occupy the smallest possible space, the keys are disposed in seven rows of seven keys each, in such a manner that those letters which most frequently occur are placed most conveniently to the position of the hands.

The entire instrument covers a surface 21 c.m. ($8\frac{1}{2}''$) by 33 c.m. ($13\frac{1}{4}''$), of which about 20 c.m ($8''$) by 20 c.m. ($8''$) belong to the finger-key arrangement. The highest part of the instrument is 29 c.m. ($11\frac{1}{2}''$).

The Automatic Cylinder Transmitter can be arranged to send currents in the same direction as well as alternating currents, with or without earth discharge, according to the circuit for which it is required.

In the first case the receiving instrument may be a simple Morse inker, and, in order to furnish a station with the automatic instrument, it is only required to change the Morse transmitting key for the Automatic Cylinder Transmitter.

The transmitting capacity of the apparatus depends upon the rapidity with which the telegraphist is able to work the finger-keys. A thoroughly efficient telegraph operator could work five keys a second, which under the condition that the mechanism of the apparatus be regulated accordingly, produces 300 signs in a minute, including the spaces between the words. If we take 200 letters as being required for a complete message (33 words), the apparatus thus transmits 90 messages per hour, which is about double the practical capacity of the "Hughes" apparatus.

The Cylinder Transmitter thus offers the advantages of automatic telegraphy (that is: augmented speed, with exclusion of defect arising from transmission by hand), without adding any difficulties to the telegraph service, and the Automatic Transmitter may be used at any moment in place of the usual Morse transmitting key.

Figs. 1 and 2 show the principal points of the instrument, omitting the less essential parts for the sake of clearness. The large plate gives a perspective view of the entire apparatus.

The characteristic part of the instrument consists of a cylinder D, which revolves on its own axis.

The periphery of the cylinder is fitted with sliding-pins *s s* (see fig. 2) placed close to each other, and parallel to the axis of the cylinder.

These pins, when pushed at one end by means of the puncher *n*, are displaced, to a certain extent, in the direction of the axis.

Groups of displaced pins of certain combinations constitute the various types for the automatic transmission of the signals, so that three displaced pins in close connection represent a *dash*, and a single displaced pin between two in their normal position represents a *dot;* one or more not displaced signify an interval of more or less length.

When pressing down a finger-key a group of pins is displaced from its normal position at the circumference of the cylinder, the group always corresponding to the letter of the finger-key.

The cylinder rotates under the effect of a weight or watchspring to such an extent as corresponds to the length of the given signal, including the space between it and the next signal; the cylinder then presents a new series of pins to the punchers *n*, which latter effect the displacement of pins through the movement they receive from the finger-keys.

Each finger-key T (see fig. 2, of which only one is shown in the drawing) is in connection with a vertical metal-plate S in such a manner that, when pressing down the finger-key T, one of these plates is pushed forward. The projections upon these metal plates S push forward a series of horizontal plates Q Q, of which there are 19, each having a corresponding double lever H. These levers are provided with punchers *n*, so that when the plates Q are pressed forward they act upon the levers H, which push forward the sliding-pins *s s* (placed at the circumference of the cylinder D) by means of the punchers *n*.

A pointer *i* connected to the axis *m* (over which the cylinder D rotates independently) is geared to the clockwork within the cylinder, and is set in motion by the spring F, which, being attached to the spindle *m*, is caused to wind up each time the cylinder rotates.

The cylinder D has ratchet teeth *c*, in which engages a spring pawl *a*, having an inclined projection *f*, and while this pawl is engaged with the ratchet teeth the cylinder remains at rest. When one of the levers H is moved by the action of a finger-key, so as to push forward one or more of the pins, these latter, at the same time, disengage the pawl *a*, and the cylinder D, acted on by the weight P, and clock-wheels N M, revolves till the pawl *a* again drops into gear.

The pawl is held out of gear as long as any of the protruded pins *s* are passing over its inclined projection *f*, and the width of this projection allows the cylinder to rotate for an additional length, which corresponds to the usual space between the signals,

It may here be remarked that the punchers n act in such a manner that, after pushing the pins tacts to be made, by which currents are sent into the line wire.

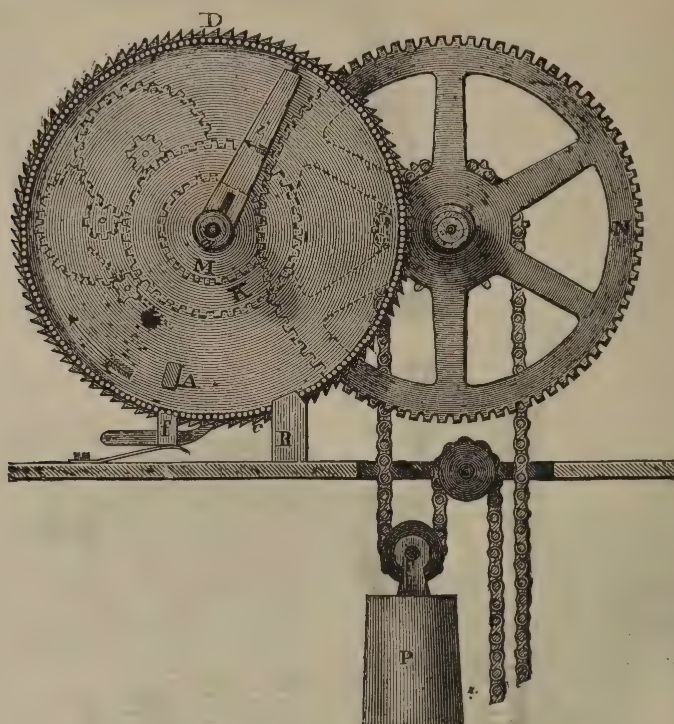
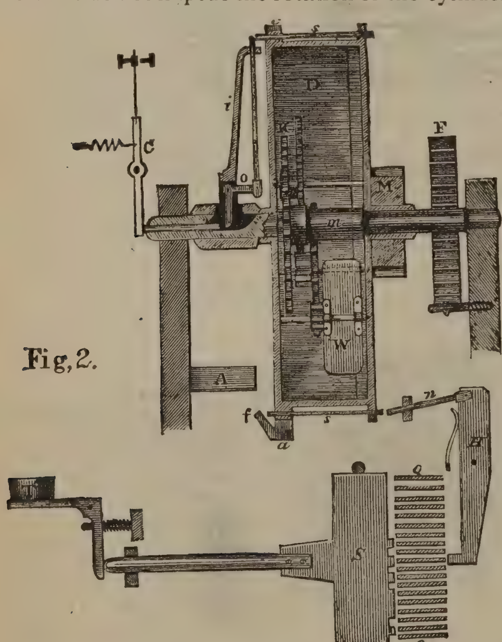


FIG 1.

forward, they pass beneath the line of pins, and therefore do not impede the rotation of the cylinder.



The pins, after passing the pawl a, are carried round with the cylinder in their protruded position, and the pointer i, in passing over them, causes con-

The mode in which the pointer i passes over the protruded pins (thus causing contact between battery and line) is the following:—On the pointer, near its axis, is mounted a bell-crank lever o, from one arm of which a wire extends radially along the pointer beyond its end, and from the other arm of which a wire extends axially through a hollow part of the spindle m, on which the pointer is mounted.

When the pointer i passes over a protruded pin the radial wire is pushed inwards, and the axial wire is thus pushed outwards, and moves a contact lever C, mounted outside the bearing of the spindle.

The pins $s\,s$, after having caused contact to be made, are brought round by the rotation of the cylinder, so as to pass under a fixed incline R (fig. 1), whereby they are restored to their normal position.

The contact lever C corresponds to the ordinary Morse transmitting-key, which, in this case, sends, automatically, the signals into the line.t

The pointer i makes, together with he cylinder D, the jerking rotations, independently of its own movement in the opposite direction, the speed of the pointer being regulated by the fan W. According to the more or less rapidity with which the telegraphist presses down the finger-keys T T, either the jerking movement of the cylinder or the contrary movement of the pointer will prevail, that is to say, in the former case, the pointer will be carried further round, in the direction of the arrow of the cylinder, away from the stopper A (see fig. 1), and, in the latter case, it will approach the stopper, moving in the direction of its own arrow, or, in other words, the store of prepared letters

between the stopper A and the pointer *i* will either be dimished or augmented.

The entire rotation of the pointer is something less than one revolution, and, as soon as the pointer reaches the limit of the movement which is allowed for storing the letters to be telegraphed automatically, a bell rings, indicating to the telegraphist that the speed of working the finger-keys should be lessened.

As soon as the telegrapher stops working the finger-keys, no more pins are pushed out, the pawl *a* drops into the ratchet teeth, and stops the movement of the cylinder, whilst the pointer *i*, which may, at the time, be some distance behind, will still continue its rotation until it reaches the stopper A.

A NEW RELATION BETWEEN ELECTRICITY AND LIGHT: DIELECTRIFIED MEDIA BIREFRINGENT.

By JOHN KERR, LL.D., Mathematical Lecturer of the Free Church Training College, Glasgow.

(From the *Philosophical Magazine*.)

(Continued from page 284.)

14. *Fifth experiment.*—A compensating slip is introduced between the dielectric and the analyzer; all the other arrangements and the procedure are as in the first experiment (6). The plane of polarization being at 45° to the horizon, and the initial extinction in the polariscope perfect, the electric force is applied, and the light is well restored. When the compensating slip is now raised into the course of the beam, and stretched horizontally, the light is weakened, and, with a proper degree of tension, extinguished perfectly. As the electric action is continued, an increasing force has to be applied to the compensator to produce extinction; but the force is always of the same kind—tension exactly or nearly parallel to the lines of electric force, or compression in a direction exactly or nearly perpendicular.

After a few trials I got this phenomenon to present itself with perfect regularity. The compensator is chosen carefully (13), and inequalities of temperature avoided. A strong electric action is kept up for any convenient time, 5 or 6 seconds to 30 or 40, till the light is well restored. The slip is introduced as in the illustrative experiment (12), and carefully bent, so that the part of it crossed by the light is stretched horizontally by a continuously and slowly increasing force. In these circumstances, and constantly, the light fades away from a very considerable brightness to an extinction as pure as I have ever got in a polariscope. After this it is almost superfluous to say that, when the compensating slip is compressed in a direction parallel to the lines of force, the light restored by electric action is always distinctly strengthened.

15. *Sixth experiment.*—Distance of the spark-terminals small (say, 3 inches), the other arrangements as formerly. The electric action is kept up for a minute or more, till the light in the polariscope is certainly constant. The neutralizing plate is then moved about, and the analyzer turned (through a small angle in any case), till the light is again well extinguished. All the optical pieces being left untouched, the primary circuit is broken; the light reappears in a few seconds, and increases continuously up to a certain permanent intensity; but the compensator to produce extinction at any stage of this increase, has to be compressed in a direction parallel to the lines of force. And this is evidently as it ought to be; for what the compensator has now to do is to reinforce the failing action of the dielectric, an action which has been proved equivalent optically to compression along the lines of force (14).

16. *Seventh experiment.*—Distance of the spark-terminals small, 1½ or 2 inches. As in the preceding experiment (15), a constant effect of electric action is obtained in the polariscope, and the light again extinguished by the neutralizing plate, which is then left untouched, as well as the other optical pieces, till the end of the experiment. The electric action being still kept up, the distance of the spark-terminals is suddenly increased up to 5 or 6 inches; the light soon reappears and is allowed time to come out distinctly. When the primary circuit is now broken, the light fades away to extinction, and afterwards reappears; but before and after this passing extinction the light has contrary characters, as tested by the compensator, being extinguished in the former case by tension parallel to the lines of force.

17. From the last three experiments, or simply from the first of them, interpreted by the illustrative optical experiment (12), we infer that the dielectrization of plate glass is equivalent optically to a compression of the glass along the lines of electric force. Dielectrified glass acts upon transmitted light as a negative uniaxal with its axis parallel to the lines of force.

18. *Eighth experiment.*—All the preliminary arrangements are as in the fifth experiment (14). A strong electric action (spark of 6 inches) is kept up without ceasing for 20 minutes, and all the optical pieces are left untouched for an hour, the induction-terminals being connected with each other through the secondary coil from first to last. One thing very noticeable under such conditions is, the length of time which the light takes to fade away to extinction. In the present experiment there is a distinct, though faint, effect in the polariscope, even as long as 30 or 40 minutes after the external electric action has ceased. The effect has a constant character from first to last: the light restored by electric action is always extinguished perfectly by a right degree of tension of the compensator in a direction parallel to the lines of force. With the standard compensator (13), there is not a very great effort required for extinction at any time during the whole hour of observation.

19. *Ninth experiment.*—The analyzer is mounted in such a way that it may be moved in different directions at right angles to the beam, without rotation: the other arrangements are as in the fifth experiment. When a good effect has been obtained through the centre of the electric field, the second Nicol is moved about so as to receive the light through different parts of the dielectric.

Keeping first to the perpendicular bisector of the line joining the terminals, the intensity of the optical effect diminishes as the distance from the centre of the field increases: and this is particularly noticeable at first, while the effect is rising; but the action has always the same character, is always neutralized by horizontal tension of the compensator. As far as my means would allow, I have assured myself of the fact that, as soon as

there is a good virtual compression of the dielectric at the centre of the field, there is an effect of the same kind, a virtual compression in the same direction, beginning to manifest itself all along the equator, but more faintly as the distance from the centre of the field increases. Out of this equatorial line, and well back from the wires, the direction of apparent compression of the dielectric changes from point to point of the field, and is at some points vertical, perpendicular to the line joining the terminals. Only at points very close to the induction-wires does the compensator fail decisively to extinguish or greatly weaken the restored light.

20. In connection with the preceding facts, I may mention that under certain conditions, in the fifth experiment, the compensator does not extinguish the restored light all at the same time, but produces a very dark broad band, which descends from the outer parts of the field towards the centre, as the tension of the compensator increases. This happens for instance, though not very regularly, when the electric force is very intense from the beginning, and the optical effect is just beginning to show itself; it happens also when the lines of force are inclined to the horizon, so that the fine vertical band of flame seen through the centre of the dielectric crosses the equator of the field at about 45°. In these cases there appears to be an unusually rapid variation of birefringent action through the part examined of the electric field.

I have now done with the dielectric of plate glass. Half-a-dozen other solids were tried; and I will conclude with a short account of the only two of them which gave results worth mentioning. The great difficulty was to get a sufficiently strong superficial insulation, the masses being too small. In only one case, that of Iceland spar, was the dielectric perforated by discharge without giving a clear effect; but I think the crystal had received a predisposing flaw in the operation of boring.

21. *Dielectric of Resin.*—This is a piece very similar to the dielectric of plate glass in form, size, and adjuncts. A quantity of clear amber resin is kept at a gentle fusion for some time till it is free from air-bubbles; it is then poured into a suitable mould and left to cool. Two thick stocking-wires of steel, previously fixed in the mould, along one line through its ends, remain imbedded as induction-terminals in the solid resin, leaving less than ¼ of an inch of clear dielectric between them at the centre of the block. The polarized light enters and leaves the central part of the block through small squares of thin plate glass, which are in optical contact with the resin and parallel to each other.

This dielectric, even the best specimen of it, is far inferior to the dielectric of plate glass. It gives evidence of permanent and irregular strain in the neighbourhood of the terminals; it exerts a pretty strong photogyric action in the polariscope, separating the blue and red by a small angle; it is also imperfectly transparent for very faint light; but its chief defect is, that it allows a spark-discharge over its surface, a length of 7 inches, before the distance of the spark-terminals has much exceeded 2½ inches. With all these deficiencies, the dielectric of resin gives a definite and regular effect; and the action is contrary to that of glass.

All the arrangements are essentially as in the fifth experiment (14). The block is tied to two insulating pillars of glass; the induction-wires of the dielectric are connected with the knobs of the secondary coil; and the light is seen through the centre of the block, midway between the terminals. A pretty good initial extinction is obtained in the polariscope between the blue and red; the light is then well restored by electric action, and the compensator is introduced between the dielectric and the second Nicol. By tension of the compensator in a direction parallel to the lines of force, the restored light is constantly and distinctly strengthened; and by compression parallel to the lines of force, it is regularly and greatly weakened, though never quite extinguished.

To test the value of these indications, I repeated the illustrative optical experiment (12) with the block of resin put in place of the large block of plate glass; and the results were satisfactory. I varied the experiment also by manipulating the block of resin itself as a compensator against the small square of compressed glass, the resin being simply pulled or pushed gently at both ends; and the results were equally distinct. The lines of stress being parallel, compression of glass and compression of the resin always reinforced each other, compression of glass and extension of the resin always counteracted each other, but never down to perfect extinction. It is true that these last results might be due more or less to the thin plates of glass which limit the resin. From all the observations, I infer that dielectrization of resin is optically equivalent to tension of the resin along the lines of force.

22. *Dielectric of Quartz.*—This is a plate perpendicular to the axis, made as for ordinary experiments in the polariscope, thickness 3 millims., length 20. Two fine holes are drilled into the plate as in the dielectric of plate glass, their bottoms flat, and with one-sixteenth of an inch of clear crystal between them. Wires of copper are inserted in the borings, and are fixed along with the crystal to simple bearings made of glass rods; and the whole piece is coated very deeply with fused lac, a narrow window being left at the centre of the plate. The action of the crystal in the polariscope is well neutralized by a contrary plate of equal thickness; the other arrangements are as in the fifth experiment. With my rough apparatus the adjustments are so troublesome that I have executed only one short series of obervations, of which I append all the notes preserved.

Distance of spark-terminals ½ inch: a faint but clear restoration of the light from almost perfect extinction; the compensator not working distinctly; the insulation perfect.

Distance 1 inch: the light clearly restored by electric action, and then well extinguished by tension of the compensator parallel to lines of force. The insulation is now failing, sparks passing occasionally over the service of the lac near the crystal.

Distance ¾ inch: the insulation still defective; the light well restored by electric action and then well weakened by horizontal tension, and strengthened by compression. From what I have seen in some other experiments, I think that the effects in this case and the preceding may have been produced wholly or partially by slight changes of

temperature, due to occasional spark-discharge over the surface of the crystal.

Distance again ½ inch: the insulation again good. In this case it is noticed that, before the electric force is applied, while the body of the light is barely perceptible in the polariscope, there is a short length of it from the apex downwards (due exactly through the centre of the electric field) which is perfectly extinguished. By electric action this upper part of the light is restored very clearly, and is then as clearly extinguished by tension of the compensator parallel to the lines of force.

23. Upon the whole, though better experimental results are desirable, I consider it proved that dielectrified quartz (like glass) acts upon transmitted light as if compressed along the lines of force, while dielectrified resin (unlike glass) acts as if extended along the lines of force.

24. *Theory.*—Faraday's views as to the constitution and function of dielectrics apply here very aptly.

When the induction-terminals are charged, the particles of the dielectric throughout the field are electrically polarized, and tend accordingly to arrange themselves end to end, and to cohere in files along the lines of force, just as iron filings do in a magnetic field. As far as this tendency of the polarized particles towards a file arrangement along the lines of force takes effect, there is a new molecular structure induced in the dielectric.

If we neglect the influence of ordinary strains transmitted from point to point of the solid, and assume, as a good first approximation warranted by facts (19), that the change of molecular arrangement at each point is determined solely or principally by electric force at the point, we cannot easily suppose the new structure in a dielectric, originally isotropic, to be anything else than uniaxial, symmetrical at each point with reference to the line of force through the point. And, even in the case of an æolotropic body, we may assume, as a simple and sure approximation to the truth, that th e effect of electric force is to superinduce a uniaxial structure upon the primitive structure.

The uniaxial structure thus induced by dielectrization has been experimentally detected and characterized by birefringent action in three cases. As a matter of fact, it appears to be negative in glass and quartz, but positive in resin.

The electric force has probably a certain resistance to overcome, something analagous to coercive force in the case of magnetism. A sensible time is therefore required for the development of the uniaxial structure by electric action, and for its disappearance after the electric action has ceased. Under an intense and long-sustained electric force, the new structure of the dielectric may assume the character of a very stiff, and, perhaps, permanent set, analagous to permanent or subpermanent magnetism (18). We shall see afterwards, as might indeed be expected, that there is nothing similar to this in the phenomena presented by dielectrified liquids.

Contrary electrizations rapidly succeeding one another exert contrary actions of electric polarization, but conspiring actions of molecular arrangement: they are therefore as effective as a continued electrization in one direction; and a Rhumkorff's coil is as effective as an electrical machine of equal strength.

I have made some experiments, and have had a good many reflections, bearing on other explanations of the phenomena; and I think it not unlikely that strains due to the mutual actions of intensely charged shells of the dielectric, or strains due to changes of temperature, may have something to do with the facts. But in the meantime I offer the preceding remarks as a sketch of what appears to me to be the only probable theory.

MILITARY TELEGRAPHS.

According to the *Augsberg Gazette*, the most complete and extensive telegraphic organization is possessed by Russia. Since the changes effected in 1873 seven parks have been established, each comprising three divisions—the first destined to establish, in time of war, telegraphic communication on the most advanced line; the second, to unite the head-quarters with all the necessary points; the third to repair the conductors. The material of the first two divisions enables them to put up the wires for a length of between ten and twelve miles, to which the reserve brigade can add others ten miles long. It is only since 1856 that measures were taken in Prussia to organize a system of portable telegraphs. This material was utilized in 1864, during the war with Denmark, and in 1866, in the war with Austria. During the first campaign it was composed of two divisions; in the second, of four. It was during the war of 1866 that it was shown what invaluable services a military telegraph could render. The lesson then learned was immediately utilised, and when the war of 1870 broke out, the field telegraph was composed of 12 divisions, commanded by a superior officer. The service, as at present constituted, has no organization for times of peace; and the battalion of pioneers of the guard and the fourth battalion of pioneers in garrison at Berlin or at Magdeburg supply the elements. The first furnishes seven divisions, the second five, each division consisting of a detachment of pioneers of about 90 men, with three officers of engineers, seven telegraph *employés*, one officer and 50 soldiers of the Military Train, and each park having 13 waggons. Each waggon carries the material for laying four and a-half miles of wire, besides 1000 feet of cable, together with the Morse apparatus, with ten-pile batteries, for the establishment of stations. In Italy the military telegraph was first utilised on a grand scale during the operations against Ancona in 1861. From Ancona communication was established in two days between the army and the fleet, and between the head-quarters and the various isolated corps, as well as between one and the other of those corps—and the whole united to the Italian telegraphic system. But it was during the American War of Secession that the military telegraph, perhaps, played the most conspicuous part. During the space of three years the army laid upwards of 8000 kilometres of wire on land and 160 kilometres of cable in the sea. It was during this war that it was shown how useful the military telegraph might be made to carry out daring projects, to effect surprises, reconnaissances, requisitions, &c. The troops of partisans that were constantly operating upon the flanks of the armies were always accompanied by an experienced telegraphic operator, an important intelligence was

thus frequentiy received by the leader of the band. On one occasion, the mayor of Cincinnati having telegraphed to a Federal general, encamped 60 miles distant, that General Morgan intended to attempt to take the city by a *coup de main*, asked for his assistance. The dispatch was, however, intercepted, and Morgan himself replied, in the name of the Federal general, that he was about to proceed to Cincinnati, but that fresh horses would be required for his artillery, and these he would expect to find at a certain place which he designated. The horses were dispatched, and Morgan took possession of them and put them to his own cannon. At the end of the war, in the month of February, 1871, the Germans in France had, according to the *Augsburg Gazette*, 1587 miles of telegraph, and 91 stations in working order. Their telegraphic system at the end of February, 1871—besides the principal lines centred near Paris, and the circular lines round the capital—embraced St. Quentin, Amiens, Rouen, and Dieppe in the north; Alencon, Le Mans, and Tours in the west; and Orleans, Gien, Auxerre, Montbard, Dole, &c., in the south. Besides this, the telegraphic system in Germany was necessarily extended on the coasts of the Baltic and the North Sea for strategical purposes. Official military intelligence from headquarters was dispatched during the war to 1860 telegraphic stations in North Germany, and to 37 stations on the theatre of war itself.—*Evening Standard.*

ABSURDITIES OF TELEGRAPHIC CENSORSHIP IN FRANCE.

The Paris correspondent of the *New York Herald* writes as follows of the absurdities of the censorship of messages on French lines:—"Among the despatches which the administration of telegraphs in Paris have thrown into the waste paper basket this year, and refused to deliver because their contents were unintelligible to the gifted creatures employed in the department, is one very touching and ingenious. Here is the text of it: 'Third Epistle of St. John, verses 13 and 14.' In opening the Bible, and following these indications, at verse 13 will be found the following words: 'I had many things to write, but I will not with pen and ink write unto thee.' The 14th verse, also, is thus composed: 'But I trust I shall shortly see thee, and we shall speak face to face. Peace be unto thee. Our triends salute thee. Greet the friends by name.' It will thus be seen that by the simple indication in the text of the despatch there is effected a notable economy of words; and perhaps some heart may have ached grievously enough because the absurd fears of official dunces prevented its delivery. Nothing can be more ridiculous, useless, and mischievous than this censorship of telegrams which has now sprung up all over Europe. For it is clear that the least experienced of conspirators would arrange between themselves some cypher which would make their plots appear harmless in the eyes of a telegraph clerk, and none but innocent persons are ever likely to be molested by the censorship. Indeed, it is a favorite amusement of boys who have more money than wit to go and worry a telegraph clerk with a message which rightens him out of his wits, and then, after disurbing all the big wigs of the department, they show that it is only a joke. An acquaintance with the common French name of Bataille is quite a delight to the jesters of this description, for the telegraph clerks cannot maintain that M. Bataille's name and Mlle. Victoire's may not be used in a telegram without a prefix."

Notices to Correspondents.

We have received from Mr. St. Aubin, New South Wales, a paper on Quadruplex Telegraphy, but his arrangement will not work. The key arrangement is needlessly complicated. We would much rather chronicle what has been done than what can be done.

J. J. S.—If you want light literature we can commend you to the *St. Martin's Magazine.* We desire to record experience and pactice, and avoid as much as possible the highly scientific. The elementary is found in abundance in text books. The classes in the telegraphic world are so numerous that it is impossible to satisfy all. We are inundated with matter. Our chief difficulty is to select that which is most useful to the greatest number. At the same time we thank our correspondent for his suggestions.

A Tyro.—No; a sounder is best.

Inspector.—In such a case we would have connected the two circuits together, so as to have made one circuit of half the resistance. You would have spoken through them in spite of the snow.

*** Duly authenticated contributions, theoretical and practical, on every subject identified with the interests to which "The Telegraphic Journal" is the organ, will always command attention. Anonymous correspondence will be wholly disregarded. Literary communications and books for review should be addressed to the Editor; business communications to the Publishers, 10, Paternoster Row, E.C.

We learn from New York that "the Indians are very thankful for the telegraph poles on the prairie; they formerly had to ride a long distance to find a place to chain a prisoner while they tortured him."

Electric Pile of Sesquioxide of Iron.—This apparatus is contained in a sqnare glass jar. The pile is composed of a prism of charcoal which contains sesquioxide of iron in its pores, and a small rod of amalgamated zinc. The latter passes through the stopper, to the under surface of which is fixed the charcoal. A solution of ammonium chloride is used as the exciting fluid. The reactions are the same as in Léclanché's couple, in which oxide of manganese is used. When the circuit is closed, the chloride of ammonium attacks the zinc, forming a double chloride of zinc and ammonium. The latter, on being set at liberty, decomposes the sesquioxide of iron, carrying off a part of its oxygen and forming free ammonia which disappears by evaporation. This pile ceases to act so long as the circuit remains open. Its durability and force are large. Its electro-motive power is as 12 to 10 of the sulphate of copper battery, and it is thus well adapted for industrial purposes. The inventors are MM. Clamond and Gaiffe, and it is manufactursd by the latter gentleman.